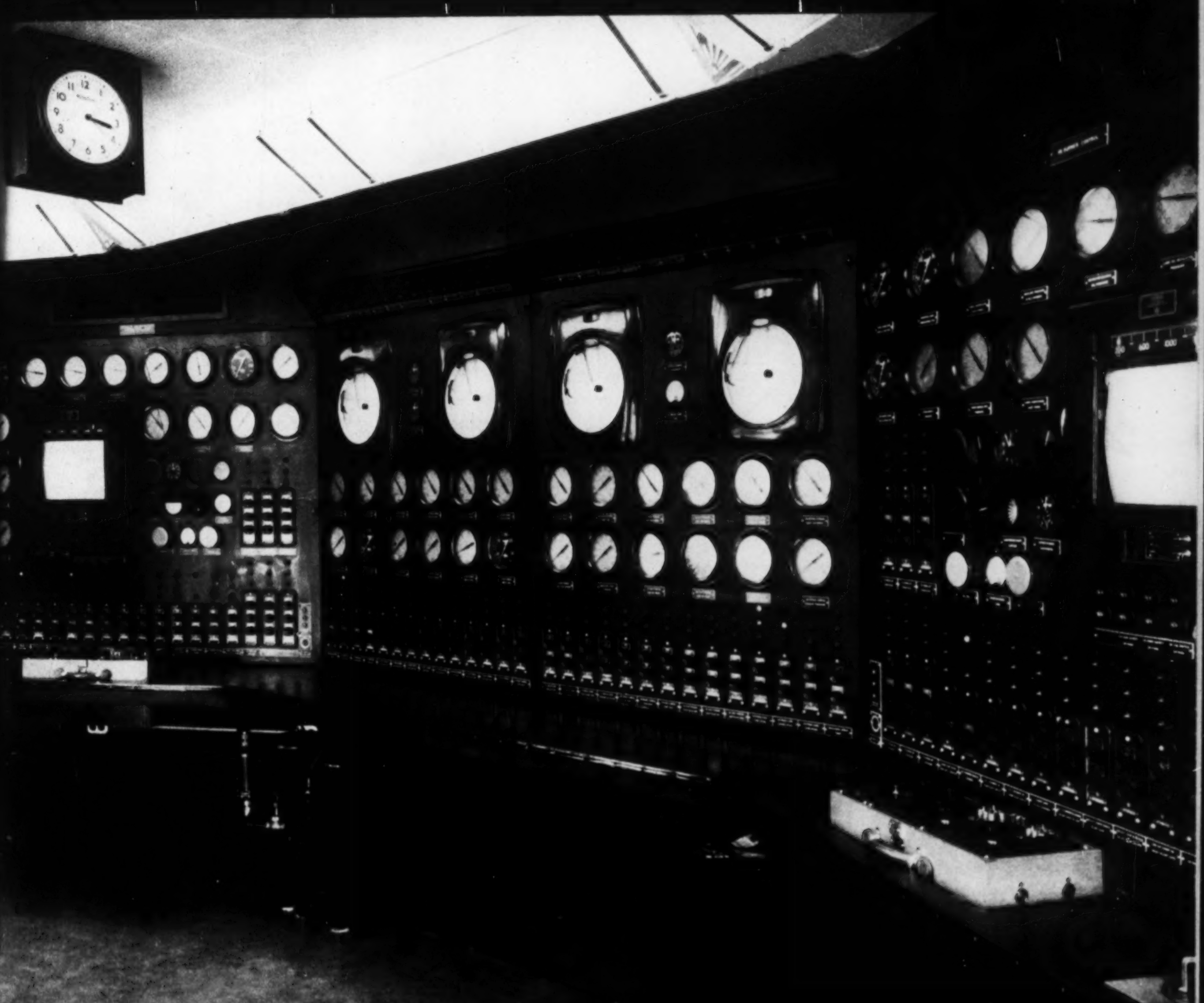
Instruments

THE MAGAZINE OF

Measurement and Control

Vol. 17
JAN.
1944
No. 1



INCLUDING Aviation Instruments

FOR VICTORY
BUY
UNITED STATES WAR SAVINGS BONDS STAMPS

TAG CELECTRAY PYROMETERS

High Speed Photo-electric (Electronic) Action

Here is a new catalog . . . which describes in complete detail the various TAG CELECTRAY Pyrometers and Resistance Thermometers for Indicating, Recording and Controlling.

In the early 1930's the CELECTRAY Instrument, with its mirror galvanometer and photoelectric detection, represented the first application of electronics to a compact Industrial Pyrometer.

With the passing of the years, many new instruments were offered, including a six-point controller in which all six points are checked within a twelve-second period and a pneumatic controller with no motor or other continuously moving parts.

These and all the other types and models of TAG CELECTRAY Pyrometers are listed and described in this new 40 page catalog. WRITE FOR YOUR COPY TODAY!

C. J. TAGLIABUE MFG. CO.
Park & Nostrand Ave's., Brooklyn 5, N. Y.

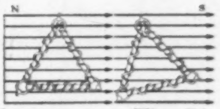
NOW AZIMUTH INDICATIONS STABLE AS A GYRO

1
2
4
5
3
3
3
1 TRANSMITTER
2 AMPLIFIER
3 REPEATER COMPASSES
4 GYRO ERECTING UNIT
5 MASTER INDICATOR

The NEW GYRO FLUX GATE* COMPASS

..provides steady, extremely accurate indications even during steep dives, fast turns, in rough weather, and near the earth's poles

HE TRANSMITTER contains the Flux Gate. This sensitive earth inductor ompass element is mounted in he wing where electromagnetic disturbances are at a minimum, and is held horizonal—even when the airplane pitches nd banks—by an electrically driven gyro. Deviation is small and a speial type compensator is used to neutralize this error, resulting in indications of magnetic heading that re practically perfect. Variation may be introduced into the system; then the dials show true heading. INDICATIONS are derived from signal voltages initiated by the Flux Gate, a triangular-shaped element whose three legs cut the earth's field at different angles, producing three different signals. This triad of signals varies with changes in heading. The tiny voltages are electronically amplified, and converted into torque, rotating the pointer of the master indicator. The associated Magnesyn* system is simultaneously set in operation, causing the repeaters to duplicate the master compass reading.



☆ ☆ ☆

The Pioneer* Gyro Flux Gate Compass System is an important member of "The Invisible Crew" of precision equipment which more than 30 Bendix plants are speeding to world battle fronts. Eclipse-Pioneer Division, Teterboro, New Jersey.

PIONEER INSTRUMENTS

*TRADE MARK OF BENDIX AVIATION CORPORATION

THE INVISIBLE CREW
Bendix
Aviation Corporation

Instruments

Vol. 17 JANUARY 1944 No. 1

SPECIAL A.S.M.E. ISSUE

COVER: Control board of airplane engine test stand at Lynn (Mass.) G-E Works. *See page* 19

EDITORIAL: "MUTUAL BENEFITS" 1
By A.S.M.E. Editor George A. Stetson

WHY ENGINEERS JOIN SOCIETIES 2
(Adapted from an A.S.M.E. pamphlet)

MESSAGE FROM I.I.&R. DIVISION CHAIRMAN 4
By Everett S. Lee

WHO'S WHO IN THE I.I.&R. DIVISION 5
By C. S. Peters, Secretary

THE 1943 MEETING'S INSTRUMENT SESSIONS 6
By Ed S. Smith

Selection of Technical Papers on Measurement and Control Presented at 63rd Annual A.S.M.E. Meeting, New York, Nov. 28-Dec. 4, 1943
(Alphabetical Order by Divisions and Authors)

APPLIED MECHANICS DIVISION
(Jointly with Society for Experimental Stress Analysis)

THE APPLICATION OF LABORATORY TEST DATA TO NEW DESIGN 28
By R. G. Anderson *Abstract*

STATIC TESTING OF AIRCRAFT STRUCTURES AND ITS RELATION TO STRESS ANALYSIS 52
By W. H. Bonell *Abstract*

APPLICATIONS OF BRITTLE-LACQUER METHOD IN STRESS ANALYSIS OF MACHINE PARTS 56
By M. Hetényi and W. E. Young *Abstract*

SOME ASPECTS OF OBSERVING THE PERFORMANCE OF LARGE MACHINERY UNDER OPERATING CONDITIONS 54
By J. H. Meier *Abstract*

TECHNIQUES FOR STRESS MEASUREMENT BY X-RAY DIFFRACTION 52
By J. T. Norton and D. Rosenthal *Abstract*

THE BONDED WIRE GAGE TORQUE METER 56
By A. C. Ruge *Abstract*

SOME PHASES OF STRUCTURAL RESEARCH AT GOODYEAR AIRCRAFT CORPORATION 58
By E. L. Shaw *Abstract*

THE DYADIC GAGE 48
By S. B. Williams *Abstract*

APPLIED MECHANICS *and* POWER DIVISIONS

RELATIONS BETWEEN THE NOTCHED-BEAM IMPACT TEST AND THE STATIC TENSION TEST 50
By C. W. MacGregor and J. C. Fisher *Extended Abstract*

AVIATION DIVISION

GAS TURBINES AND TURBOSUPERCHARGERS 56
By Sanford A. Moss *Abstract*

HIGH-ALTITUDE HOT-GAS STANDARDS FOR TESTING TURBOSUPERCHARGERS AND ENGINES 19
By E. E. Stoeckly *Nearly In Full*

AVIATION *and* HEAT TRANSFER DIVISIONS

THE "TEMP-TURB" SYSTEM OF AUTOMATIC TEMPERATURE CONTROL 24
By J. R. Campbell *Nearly In Full*

TEMPERATURE MEASUREMENT IN HIGH-VELOCITY AIR STREAMS 40
By H. C. Hottel and A. Kalatinsky *Extended Abstract*

AVIATION *and* INDUSTRIAL INSTRUMENTS AND REGULATORS DIVISIONS

RADIATION PYROMETRY IN SUPERCHARGER TESTING 36
By Victor P. Head *In Full*

HIGH-SPEED MULTIPLE-POINT POTENTIOMETER RECORDING OF THERMOCOUPLE TEMPERATURES DURING FLIGHT TESTS OF PLANES 26
By I. M. Stein, A. J. Williams and W. R. Clark *Extended Abstract*

FUELS DIVISION

NEW COMBUSTION-CONTROL METHODS FOR ALL STANDARD FUELS 34
By Robert Reed *Abstract*

INDUSTRIAL INSTRUMENTS AND REGULATORS DIVISION

MINIMIZING INSTRUMENT MAINTENANCE IN DESIGNING AVIATION GASOLINE PLANTS 9
By D. J. Bergman and G. G. Gallagher *In Full*

PROBLEMS IN OBTAINING PERSONNEL IN THE WARTIME OPERATION OF AN INSTRUMENT DEPARTMENT 10
By G. P. Bosomworth *In Full*

TRAINING OF INSTRUMENT MEN FOR GOVERNMENT MAGNESIUM AND STYRENE PLANTS 11
By Robert W. Cermak *In Full*

WARTIME MATERIAL ECONOMIES IN INSTRUMENT DESIGN 15
By Theodore A. Cohen *In Full*

SOME EXPERIENCES IN PUTTING RECENT PROCESS UNITS INTO OPERATION 13
By H. F. Moore and W. C. Ludi *In Full*

INSTRUMENT PIPING, TUBING AND FITTINGS DURING WARTIME 7
By Ralph D. Webb *In Full*

MATERIALS HANDLING DIVISION

THE THEORY AND DESIGN OF ELECTRONIC CONTROL APPARATUS 46
By W. C. Cockrell *Extended Abstract*

APPLICATION OF ELECTRONIC CONTROL 42
By E. H. Vedder *Extended Abstract*

TEXTILE DIVISION

INSTRUMENTATION AND CONTROL IN THE TEXTILE INDUSTRY 33
By W. B. Heinz *Extended Abstract*

ELECTRONIC INSTRUMENTATION IN THE TEXTILE INDUSTRY 30
By Stephen T. Herr *Extended Abstract*

New Instruments Department 62
Indicators, recorders, meters, controllers, inspection devices, etc., for plant, field, aircraft and laboratory

PAPER CONSERVATION (Publisher's Statement) 68
INSTRUMENT SOCIETY NEWS 74
MANUFACTURERS' NEW LITERATURE 78
ADVERTISERS' INDEX 80

Index to Vol. 16 (1943) crowded out, will appear in February issue

---

Published Monthly on the 15th by
THE INSTRUMENTS PUBLISHING COMPANY
1117 Wolfendale Street, Pittsburgh 12, Pa.

RICHARD RIMBACH
Publisher

Major M. F. BEHAR
Editor

FIELD REPRESENTATIVES
James Condon, 36 Myrtle St., *Boston 14,* Mass. (Lafayette 0829). R. K. Farnham, 545 Fifth Ave., *New York 17,* N. Y. (Murray Hill 2-4217). Harold W. Haskett, Keith Bldg., *Cincinnati 2,* Ohio (Main 4260); Room 615, 360 N. Michigan Ave., *Chicago 1,* Ill. (Andover 4299). M. D. Pugh, 2989 Lincoln Ave., *Altadena, Calif.* (Sycamore 7-2894), James R. Wright, 916 Olive Street, *St. Louis 1,* Mo. (Chestnut 1965).

MEMBER Audit Bureau of Circulations

Annual Subscription: U. S. $2.00. Copyright 1944 by The Instruments Publishing Company. Entered as second-class matter January 26, 1932, at the post office at Pittsburgh under the Act of March 3, 1879.

Subscribers: Note that while the WPB Paper Limitation Order is in force—

1. Send notices of changes of address as soon as possible—preferably before you move. Back copies can no longer be furnished.
2. Renew your subscription before it expires. If you do not remember the expiration date, look for it on the address stencil. Renewal notices will continue to be sent before expirations, but *only one notice* will be sent to each subscriber and renewal must be received within fifteen days.
3. Circulation of *Instruments* is limited to 10,000 copies. There already is a waiting list. Names on waiting list are placed on circulation list in regular order to replace non-renewals.
4. No single copies will be sold.
5. No new or renewal foreign subscriptions can be accepted during the time that the WPB Limitation Order is in force.
6. CHANGED ADDRESSES: Copies will not be sent to replace those not received by reason of moving. Two months' advance notice should be given our Circulation Dep't to assure change of stencil in time.

E. Engin.
[illegible]

PECIAL ISSUE in honor of The American Society of Mechanical Engineers

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

. A. STETSON, Guest Editor

MUTUAL BENEFITS

IT is a great privilege to address the readers of *Instruments* directly and to acknowledge the salute which this agazine is making to The American Society of Mechanal Engineers.

The engineers of the United States of America are fornate in being well served by their technical press. Every ndustry is ably represented by ne or more magazines which ake it their business to care or the needs of specialists ust as the professional engieering society publications inister in broader and more eneral areas. There is no oom for suspicion that, editoially, there exists competition r jealousy between these two reat groups of technical jourals. Each supplements the ther, and both are necessary or the complete service the ndividual engineer requires.

One of the objectives of The merican Society of Mechanial Engineers is the dissemiation of engineering informaion. The Society interprets his objective as requiring it o permit the freest use of the apers presented at its meetngs, by other publishers of echnical and engineering agazines, provided proper redit is accorded the authors f these papers and the Soiety. Collateral publication inreases the number of readers nd the usefulness of the Soiety and of the men who share heir knowledge and experience ith their fellow engineers. Nor is this arrangement a uniateral one. The Society is onstantly benefiting from the ervices rendered to it by techical magazines and their ditors.

This issue of *Instruments,* which honors one of the ewest of the A.S.M.E. professional divisions, is an excelent example of the friendly relations between the Society nd the technical press. Through this issue the technical apers on measurement and automatic control, presented nder the auspices of several Divisions at the largest .S.M.E. Annual Meeting ever held, are made available to large and highly technical group of readers. In this issue lso these same readers are being given an opportunity to learn about the new Industrial Instruments and Regulators Division and its activities.

The Industrial Instruments and Regulators Division, which is virtually a technical society within an engineering society, began as a committee of specialists and enthusiasts within the Process Industries Division of the A.S.M.E. It is a fine group of men with common interests who have known and worked with one another for several years. They have not only established their ability and right to broaden their activities but also have found those invaluable personal contacts and friendships which such joint efforts, unselfishly undertaken, frequently engender. Something of that informal spirit of good fellowship which enriches all such common undertakings can be sensed in the "chatty" account of the Instruments sessions at the A.S.M.E. Annual Meeting, prepared by Ed S. Smith, chairman of the original committee which fathered the Division. The present chairman of the Division, Everett S. Lee, in more serious vein, describes the program of the Division and of its numerous committees.

Interest in measurements, in instruments, and in regulation and control that instruments make possible is fundamental to science and engineering. The very first volume of the *A.S.M.E. Transactions* testifies to this interest. The history of the Society's activities since 1880 shows how this interest has been cultivated throughout the years. Papers by individuals, reports of committees, descriptions of instruments and their use, examples of expanding applications to regulation in all branches of mechanical engineering are to be found in A.S.M.E. publications. As engineering advances, these subjects take on increasing importance and require a higher quality of competence to design, manufacture, apply, and interpret them. Proof of these advances lies in the recent establishment of the A.S.M.E. Industrial Instruments and Regulators Division, which event is being signalized in this issue of *Instruments.*

G.A.S.

DISPROOF of the COMMON BELIEF that a GUEST EDITOR MUST LACK EDITORIAL EXPERIENCE

Just ten years ago, in December 1933, the usual decorum of the Annual Business Meeting of the A.S.M.E. was disturbed by a group who criticized everything in general and Society publications in particular. I stood it a while, then testified:

"Mr. President, as an observant member who is the editor of a technical journal published by a private corporation, I say that in my opinion *Mechanical Engineering,* published by the A.S.M.E., is the finest technical journal in the world!"

I haven't changed that opinion . . . so you know what I think of the man I want you to meet—although the adjoining photograph fails utterly to convey the warm impression you would get if you met him in person.

George Albert Stetson was born (May 6, 1889) and reared in New Haven, Conn., the son of the first city librarian there, who served actively for 42 years. In 1910 he was graduated (Ph.B.) from the Sheffield Scientific School of Yale University, where L. P. Breckenridge, one of the ablest teachers of his time, headed the Department of Mechanical Engineering. Following a year of graduate study and teaching, he left Yale for a couple of years and returned as a member of the Department of Mechanical Engineering, remaining until Professor Breckenridge's retirement in 1923, when he left to go into business with a relative. In less than a year he was back teaching mechanical engineering, this time with Collins P. Bliss of N.Y.U., where he remained until 1928. During most of Stetson's years at Yale and N.Y.U., he was on the editorial staff of the A.S.M.E. In 1928 he took up editorial work on a full-time basis.

"By temperament and experience," he stated recently, "I am a schoolmaster of the bookist type who was trained for editorial work by my predecessor, Lester G. French, encouraged and inspired in engineering society activities by that remarkable secretary, Calvin W. Rice, and disciplined to hard work and a certain amount of realistic thinking by my associates, Colonel C. E. Davies and Miss K. W. Clendinning, without whose loyalty and example I would easily succumb to inaction and pedantry." Well, George may be "bookist" but he is neither "bookish" nor "pedantic."

—MFB

Why Engineers Join Societies

(Adapted from an ASME pamphlet, "Do You Belong?")

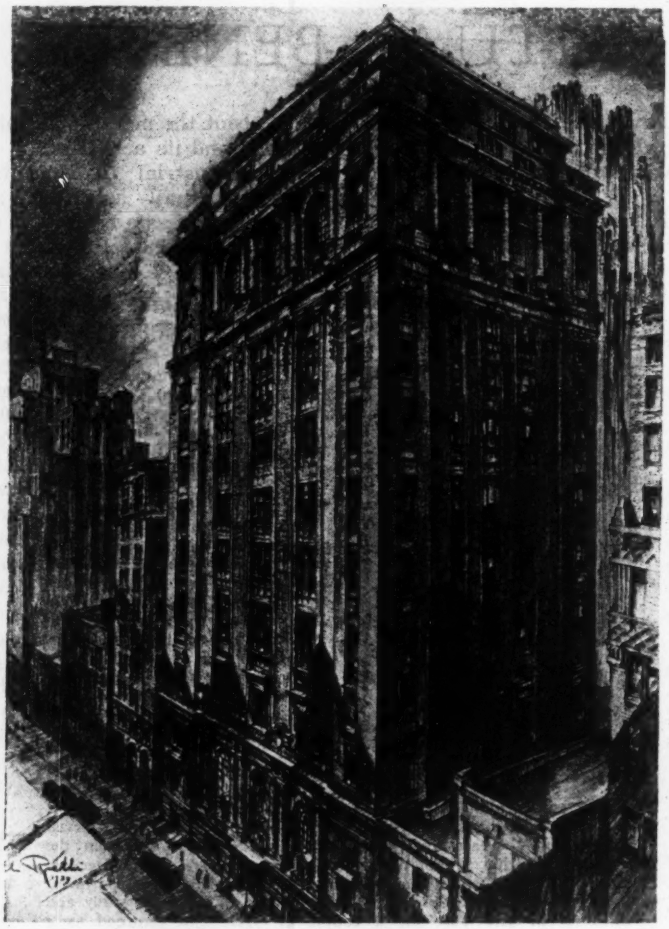
AN engineer can hold an engineering job without being a member of an engineering society. Access to technical books and magazines may be his without it. Industrial and engineering standards, approved practices and test codes are available to him if he wishes to consult libraries or to spend a few dollars for pamphlets. A nonmember can enjoy the friendship and association of engineers if he is found to be honorable and agreeable in such a relationship. He can attend many meetings of engineering societies. For a few dollars or on the invitation of a member he can be seen at banquets and receptions. He can utilize the Engineering Societies Library in New York without a membership card.

What, then, is it that *leads* men to join engineering societies if it is not a job, money, prestige, or self-satisfaction? It may be any or all of these in partial measure, but fundamentally it is much more: A sense of personal responsibility to assist in the betterment of one's occupational group and a desire to take an active part in its affairs by services that bring real satisfaction. The urge to work with one's fellows for the advancement of engineering knowledge, influence, and opportunity. A desire to play an effective role in an organization that represents one's profession—to play one's part as an engineer in whatever services to the public engineers can perform better as a profession than as individuals—to *belong*, in short, in the fullest sense of the word, to a profession.

To *belong* is to have attained the recognition of one's own abilities and attainments that none but one's peers can grant—to *be* an engineer and to be *known* as such—a distinction one cannot purchase for money if it is not deserved; something one's fellow engineers can withhold from a man if they do not consider him worthy of it.

Intangible motives, perhaps, these are, but powerful ones, none the less, and they become stronger and more appealing as they are exercised by professional men. And as a basis for cooperative enterprises they result in tangible benefits to the individual member, the engineering profession, and the public at large.

What the A.S.M.E. Means.—At present there is no single engineering society to which all engineers must belong in order to be recognized as members of the engineering profession. There are several national societies that operate autonomously, engage in special programs in their own fields, and operate jointly in matters of mutual concern. Of these autonomous organizations The American Society of Mechanical Engineers represents the field of engineering designated by its name. Membership in this Society is not only a recognition of attainment and ability; it is also an opportunity for greater achievement. Do *you* "belong"?



ENGINEERING SOCIETIES BUILDING
29 West 39th Street, New York 18, N. Y.

In this building, headquarters of the A.S.M.E., are sixteen floors occupied by national engineering societies and their joint agencies including the Auditorium and Library. [Drawing by Lili Réthi.]

The Mid-West Office of the Society is located in the Engineering Building, 205 West Wacker Drive, Chicago 6, Ill.

A.S.M.E. Services: To Its Members.—For sixty-three years The American Society of Mechanical Engineers has worked to enhance the status and prestige of engineers and to foster the ideals, practices, and ethics that mark mechanical engineers in their own minds and in the opinion of the public as professional men. Membership in a society dedicated to these objectives links an engineer with the best elements of his profession. It is testimony to the world at large that the engineer has been adjudged by his fellows as being worthy of assuming the obligations that membership implies.

The 17,000 Juniors, Members, and Fellows of the A.S.M.E. represent men of all ages in all branches of mechanical engineering. They serve many industries. They are engaged in design, research, testing, invention, education, patent law, and consulting practice. They hold positions varying from apprenticeship to presidency and ownership of enterprises.

In addition to these 17,000 members, more than 5700 Student-members are enrolled in 120 Student Branches.

Every member of the A.S.M.E. is entitled to enroll in three of the 18 professional divisions which are engaged in developing technical knowledge. He may participate in several Society meetings held annually and in the national meetings of the divisions. He has access to the Engineering Societies Library and to its many services. If he is looking for a position or if he wishes to change his position he may avail himself of the Engineering Societies Personnel Service, Inc. All these opportunities and privileges he enjoys, not because he pays something as he buys a suit of clothes, but as one whose active support makes the opportunities and privileges possible. He is not an outsider or a hanger-on; he pulls his own weight in the boat.

A member may also enroll in one of the A.S.M.E. Local Sections, many of which are affiliated with local engineering clubs and societies. In these sections, which function in 70 communities in the United States and Canada, engineers enjoy the privileges of professional association and contact with other engineers and may attend local meetings devoted to technical discussions and economic and social betterment. Here again he identifies himself locally with the profession to which he owes his professional status.

←—1943 — MEASUREMENT-MINDED A.S.M.E. PRESIDENTS — 1944—→

HAROLD V. COES, vice-pres. Ford, Bacon & Davis, was born in Hyde Park, Mass. He is an M.I.T. grad (B.S. '06). From 1908 to 1911, while with the Liquid Carbonic Co., he assisted in the design of, and built and operated the then largest liquid-carbonic-acid plant in the world. In 1914, he became V-P&G-M of the Sentinel Mfg. Co. (automatic devices). In 1917, he joined Gunn, Richards & Co. and, as industrial engineer, reorganized production in munitions plants of Canada. His work was so successful that he was invited to join Ford, Bacon & Davis, of which he became a partner in 1937 and, in 1941, V-P. Mr. Coes has been active in the A.S.M.E. since 1907, serving as V-P in 1927 and 1932-1934. His committee work includes several Chairmanships. He is the Society's representative on the Engineers' Defense Board and is prominent in the American Management Association and other societies.

ROBERT M. GATES, president Air Preheater Corp., formerly vice-pres. The Superheater Co. and Combustion Engineering Co., was born in Iowa, Sept. 7, 1883. After graduating from Purdue (B.S. in M.E.) 1907, he worked with the Browning Co., then practiced as consulting engineer until 1912 when he joined the Thew Shovel Co. In 1918 he became Eastern manager for the Lakewood Engineering Co. In 1922 he joined The Superheater Co. He has participated in the design and construction of fuel, steam-generating and process-industries equipment including the world's largest high-pressure boilers. Mr. Gates has served as chairman of WPB-A.S.M.E. War Production Clinics. He has written many articles on materials handling, power generation, personnel and management. He is active in more than a dozen societies.

Every member receives without extra cost the monthly *Mechanical Engineering* (with which is published the A.S.M.E. News), and, if he desires it, the *Transactions*, which is issued monthly and includes the *Journal of Applied Mechanics*. He receives, free of charge, the Membership List, and the annual A.S.M.E. Mechanical Catalog and Directory, and he may purchase at reduced rates the Codes and Standards of the Society, and special books and publications issued for sale. He is not merely a subscriber; he is a supporter of these publications. They are *his*.

Opportunity to serve on one or more of the Society's national and local committees, of which there are several hundred, provides additional means by which the member increases his prestige and professional contacts. The satisfaction that comes from serving fellow engineers, the profession, and the public, and from the friendships formed as a consequence of committee membership is one of the prized and enduring benefits of membership. To the member these opportunities and satisfactions are genuine, for it is his membership that makes them possible.

> "THE OBJECTS OF THIS SOCIETY *are to promote the art and science of mechanical engineering and the allied arts and sciences; to encourage original research; to foster engineering education; to advance the standards of engineering; to promote the intercourse of engineers among themselves and with allied technologists; and severally and in cooperation with other engineering and technical societies to broaden the usefulness of the engineering profession.*"
>
> —CONSTITUTION, A.S.M.E., ARTICLE C2, SECTION 1

A.S.M.E. Services: To Engineering.—The A.S.M.E. participates in a variety of activities for the benefit of the entire engineering profession as well as its own members by means of technical meetings, publications, and the stimulation of research; the codification of engineering construction, operation, testing, and safety practices; industrial standardization under the procedure of the American Standards Association; coöperation for joint action with other engineering groups, such as the Engineering Societies Library, the Engineering Societies Personnel Service, Inc, The Engineering Foundation (research), the Engineers' Council for Professional Development (devoted to student selection and guidance, accrediting of engineering curricula, training of young engineers, and professional recognition of maturing engineers); the conferring of medals, prizes, and awards; a code of ethics; and attention to legislation and public discussions affecting the economic and professional status of the engineer. Without engineering societies, these activities would have no continuing existence, and the profession little or no influence.

A.S.M.E. Services: To the Public.—On behalf of the public welfare the A.S.M.E. maintains contacts with numerous municipal, state, and federal agencies, fosters a high standard of professional ethics, creates international goodwill through its relations with engineering groups in other countries, contributes to the advancement of engineering knowledge, and, through members nominated on invitation for special services, makes available expert opinion, advice, and skill to governmental and educational bodies.

Meetings.—The A.S.M.E. holds annually several national Society meetings in widely scattered areas, featuring technical sessions, plant visits, social events, committee meetings, and general lectures.

Local Sections.—Every A.S.M.E. member may also be a member of one of 70 Local Sections, which carry on programs of engineering, professional welfare, and civic work all over the United States. Each Section receives financial and other assistance from the parent Society.

Student Branches.—More than 5700 mechanical engineering students are members of 120 A.S.M.E. Student Branches located throughout the country. Upon graduation, every Student-member may transfer to the Junior grade of membership. Student Branches conduct their own activities.

Professional Divisions.—The A.S.M.E. Professional Divisions plan the technical features of national Society meetings, hold their own national meetings, have their own officers and committees, and engage in special activities such as plant inspection trips. Every A.S.M.E. member may register in any three of the following eighteen divisions:

Applied Mechanics
Aviation
Fuels
Graphic Arts
Heat Transfer
Hydraulic
Industrial Instruments and Regulators
Management
Materials Handling
Metals Engineering
Oil and Gas Power
Power
Process Industries
Production Engineering
Railroad
Rubber and Plastics
Textile
Wood Industries

There is also a Consulting Engineering Professional Group.

Special Council Committees are appointed from time to time, as need arises. Two of current interest are those on War Production and on Post-war Planning.

476 Technical Committees.—Safety, test, and construction codes, research in many fields, and industrial standardization are sponsored by 476 A.S.M.E. technical committees on which 2471 engineers are serving.

Publications:

Mechanical Engineering.—The Society's monthly Journal, a high-grade technical magazine, contains papers and addresses of broad general interest, editorials, book reviews, and other features.

Transactions.—Issued monthly (four numbers being the *Journal of Applied Mechanics*). Contains original technical papers.

Codes and Standards.—These are the published work of A.S.M.E. Technical Committees. Frequently revised and issued irregularly. The Fluid Meters reports, Power Test Code instrument pamphlets, etc., are well-known to many *Instruments* readers.

General Publications.—Biographies, bibliographies, handbooks, and pamphlets of various kinds are published from time to time.

How to Become an A.S.M.E. Member.—A candidate must first file an application, endorsed by several A.S.M.E. members of known standing who are sufficiently familiar with the quality of his achievements as an engineer to act as his sponsors. They must vouch for his personal character.

There are four grades of membership in the A.S.M.E.:

FELLOW—A Fellow shall be an engineer who shall have distinct engineering attainment, 25 years of active practice* in the profession of engineering or teaching of engineering in a school of accepted standing, and shall have been 13 years in the grade of Member, or Associate-Member, or 10 years in the former Member grade. An engineer lacking these qualifications but who has distinguished engineering or scientific attainments may be elected a Fellow by unanimous vote of Council members voting. Initiation fee, $30; annual dues, $25.

MEMBER—30 years or over—nine years' active practice in engineering,* three of them in responsible charge of important work; qualified to design as well as to direct engineering work. Initiation fee, $25; annual dues, $20; transfer to Fellow, $5.

ASSOCIATE—30 years or over—An Associate need not be an engineer but must have a record of recognized leadership in some profession, or branch of industry, or science relating to engineering, and shall be qualified to cooperate with engineers in the practice of their profession. Initiation fee, $25; annual dues, $20.

JUNIOR—A Junior Member shall be a graduate of a school of engineering of accepted standing or one who has equivalent attainments. Initiation fee, $10; annual dues, $10 under age 30, $15 ages 30 to 32, inclusive, and $20 thereafter; transfer to Associate or Member, $10 (excepting applicant under age 33, in good standing for 5 consecutive years, may be transferred without fee).

STUDENT-MEMBER—A Student-member shall be a student regularly enrolled and pursuing an approved engineering curriculum in a school having a Student Branch of this Society. A Student-member shall not remain in this grade beyond the end of the Society's fiscal year in which he terminates his enrollment as a Student. Annual dues, $3.

---

*Graduation from an engineering school of accepted standing shall be considered equivalent to four years of active practice.

A Message from the Chairman of the New Division

EVERETT SAMUEL LEE, Engineer in Charge of General Engineering Laboratory, General Electric Co., was born at Chicago, November 19, 1891, and received the degrees of B.S. in E.E. from the University of Illinois in 1913 and of M.S. in E.E. from Union College in 1915. From 1913 to 1916 he was an instructor in electrical engineering at Union College and a laboratory assistant at G-E. He was with the Locomotive Stoker Co., Chicago, 1916-17 and, after a year in charge of machine gunnery at the U. S. Army School of Military Aeronautics at Urbane, Ill., returned to G-E in 1918. He has been with G-E continuously since then, becoming Assistant Engineer of the General Engineering Laboratory in 1928 and assuming his present position in 1931. . . . Up to this point the wording follows that supplied by the American Institute of Electrical Engineers (of which Mr. Lee is said to be the most active Fellow in its history) but the A.I.E.E. does not elaborate on the words "his present position." We can't let it go at that! Regardless of his title and of his Schenectady duties, his position is often called "Good-Will Ambassador to All Engineering Societies." Space limitations prevent detailed listing of his achievements on committees and boards and as an officer of various societies. In the A.S.M.E. he has been active in the previous Committee on Industrial Instruments and Regulators before becoming Chairman of the Industrial Instruments and Regulators Division. He is also a member of the Schenectady Kiwanis International, but to engineers in general his most important Chairmanship at present is that of the Engineers' Council for Professional Development—a "super duper" body made up of delegates from national engineering societies. To G-E men and to electrical instrument men everywhere, he is known for his many years of work in the field of electrical measurements. And to members of Measurement and Control Societies in various parts of the country he is known as the giver of a lecture on "Measurements" which is both instructive and delightful . . .

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
INDUSTRIAL INSTRUMENTS AND REGULATORS DIVISION

Schenectady 5, N. Y.
December 23, 1943.

To the editor of *Instruments:*

Those who are active in the work of instruments and measurements recognize their universality. To those who are not so familiar with this, I have found that the Lord Kelvin statement brings an instant response, for from their own experiences they recognize,

> "that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of Science, whatever the matter may be."

The scope of the Industrial Instruments and Regulators Division of the American Society of Mechanical Engineers can be as broad as the Lord Kelvin statement. At the moment we are working in a more restricted portion of the measurements field, that of industrial instruments and regulators, but this portion is a most interesting one and has in it still many opportunities for advancement even though the advances that have been made represent one of the most remarkable of engineering achievements. To make this even better is our aim.

To those in the work there is every opportunity for extension appropriate to their abilities. The opportunities which exist are limited only by our knowledge of the physical sciences and our ability to operate within that knowledge. The associations available through the Industrial Instruments and Regulators Division of the A.S.M.E. give opportunity in the participation and the recording of this advance.

In the past year we have set up an organization whereby the members of the A.S.M.E. interested may participate. This is a Division organization built upon the previous Committee organization under the leadership of Ed S. Smith. The committee personnel at present is given on the page which I understand you are assigning to Division Secretary Peters.

A.S.M.E. members who are interested may be members of the Division; others may be associated with the work. The Division will contribute wherever it can to the service of those interested in the field of Industrial Instruments and Regulators, and in a larger sense to those interested in the broader aspect of measurements.

The field is enormous as it extends into the multitudinous processes in our whole industrial nation-wide plant. We find here theory, design, and application. The theory includes the physical phenomena involved together with the application of mathematics to bring the physical concepts into a quantitative usefulness. The design includes the description of the designs of industrial instruments and regulators together with their performance. The application includes the actual application of instruments and regulators, their installation, maintenance and repair, and the building up of instrumentation organization in industrial companies for instrument application and maintenance. Surrounding all of this is a proper terminology together with a recording of progress in papers to include also bibliography and translation. The whole field is thus represented in our Division organization.

Of the nearly 100 members of the Division some 60 of them were present at the Annual Meeting of the Society which you are here reporting. Attendances of 150 are in the records for the two sessions held under the auspices of the Industrial Instruments and Regulators Division. Such interest and such enthusiasm attests to the importance and to the value of the work.

It is the life work of many measurements engineers. It lives in American industry today where it is the vital element in process control. Its importance is fundamental.

We appreciate your interest in giving your readers an opportunity to learn of these activities. You have constantly progressed the thoughts, aspirations, advantages, accomplishments, and opportunities in the instrumentation field. May these be further extended to the advantage of all.

Very truly yours,

EVERETT S. LEE, *Chairman*

"A Technical Society within an Engineering Society"

Guest Editor Stetson (A.S.M.E. Editor) uses the above expression (see Page 1) to characterize the new I. I. & R. Division. On this page, Division Secretary Peters supplies all the "who's who" data, as of Dec. 6, 1943.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
INDUSTRIAL INSTRUMENTS AND REGULATORS DIVISION

OFFICERS

Chairman, Everett S. Lee

Secretary, J. C. Peters

DIVISION MEMBERS

Bean, L. J., The Bristol Co., Waterbury 19, Conn.
Behar, M. F., 245 Melwood St., Pittsburgh 13, Pa.
Belaef, N., 68 Baker Ave., Westport, Conn.
Bergman, Dr. D. J., 310 S. Michigan Ave., Chicago, Ill.
Boelter, Prof. L. M. K., University of California, Berkeley, Calif.
Bradley, Ingalls S., 304 Clay Avenue, Rochester 13, N. Y.
Bristol, E. S., Leeds & Northrup Co., 4901 Stenton Ave., Phila. 44, Pa.
Croft, Prof. Huber O., University of Iowa, Iowa City, Iowa.
Davis, Capt. C. R., 12 Ormsby Crescent, Toronto 12, Canada.
Draper, Prof. C. S., Mass. Inst. of Technology, Cambridge, Mass.
Eckman, Donald P., Brown Instrument Co., 4497 Wayne Ave., Phila. 44, Pa.
Eskin, S. G., Robertshaw Thermostat Co. Research Lab., 1201 Washington Blvd., Pittsburgh 6, Pa.
Exline, Paul G., Gulf Research & Development Co., Box 2038, Pittsburgh, Pa.
Goetzenberger, R. L., Brown Instrument Co., Wayne and Roberts Avenues, Phila. 44, Pa.
Goglia, Prof. M. J., Dept. of Mech. Eng., Univ. of Illinois, Urbana, Ill.
Gorrie, H. H., Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio.
Gradisar, A. A., Spencer Lens Co., Buffalo, N. Y.
Graff, Paul, E. B. Badger & Sons Co., 75 Pitts Street, Boston 14, Mass.
Grebe, Dr. John J., The Dow Chemical Co., Midland, Mich.
Haigler, Edmund D., The Foxboro Company, Foxboro, Mass.
Hanssen, A. J., 740 5th Ave., South, Clinton, Iowa.
Harlow, James H., 1000 Chestnut St., Philadelphia, Pa.
Hartford, Ernest, A.S.M.E., 29 W. 39th St., New York 18, N. Y.
Hawkins, Prof. G. A., Mech. Engrg. Bldg., Purdue Univ., Lafayette, Ind.
Heinz, W. B., Middlebrook Road, Bound Brook, N. J.
Hrones, Prof. John A., Mass. Inst. of Technology, Cambridge, Mass.
Hubbard, K. H., Taylor Instrument Companies, Rochester 1, N. Y.
Hunter, James W., Sherron Metallic Corp., 1201 Flushing Ave., Brooklyn, N. Y.
Irmer, C. B., Leeds & Northrup Co., 4901 Stenton Ave., Phila. 44, Pa.
Kavan, Prof. C. F., Columbia University, New York, N. Y.
Keppler, P. W., 41 Sherman Street, Foxboro, Mass.
Kimball, James L., 10 Walnut St., Danvers, Mass.
Kohn, E. J., Tennessee Coal & Iron Co., Birmingham 8, Ala.
Lee, Everett S., General Electric Company, Schenectady 5, N. Y.
Lee, Dr. Geo. H., 307 W. Sibley, Cornell Univ., Ithaca, N. Y.
Markson, A. A., Hagan Corp., 323 Fourth Ave., Pittsburgh 30, Pa.
Mason, Dr. H. L., Taylor Instrument Companies, Rochester 1, N. Y.
McMahon, The Kellex Corp., 233 Broadway, New York 7, N. Y.
Moore, Harry F., Standard Oil Development Co., P. O. Box 37, Elizabeth, N. J.
Olive, T. R., McGraw-Hill Publishing Co., 330 W. 42nd St., New York, N. Y.
Peters, J. C., Leeds & Northrup Co., 4901 Stenton Ave., Phila. 44, Pa.
Philbrick, Geo. A., Mass. Inst. of Technology, Cambridge, Mass.
Posey, Prof. C. J., Engrg. Bldg. State Univ. of Iowa, Iowa City, Iowa.
Roberts, Richard F., 136 Cleveland S., Orange, N. J.
Schofield, W., Leeds & Northrup Co., 4901 Stenton Ave., Phila. 44, Pa.
Smith, Ed S., Research Engrg. Dept., Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Smith, Geo. W., Box 1346, Pittsburgh, Pa.
Smith, Ronald B., Elliott Company, Jeannette, Pa.
Sperry, Elmer A., Jr., Sperry Products Inc., 1505 Willow Ave., Hoboken, N. J.
Sperry, Albert F., 2326 S. Michigan Ave., Chicago 16, Ill.
Sprague, Philip T., The Hays Corp., Michigan City, Ind.
Stein, I. Melville, Leeds & Northrup Co., 4901 Stenton Ave., Phila. 44, Pa.
Strowger, E. B., Buffalo, Niagara & Eastern Power Corp., Buffalo, N. Y.
Trinks, Prof. W., 1610 First National Bank Bldg., Pittsburgh, Pa.
Turner, Ralph E., 53 W. Jackson Blvd., Chicago, Ill.
Webb, R. D., 1 Lindy Road, Charleston 4, W. Va.
Wichum, Maj. Victor, 1291 Dean Street, Brooklyn, N. Y.
Wood, W. D., Taylor Instrument Companies, Rochester 1, N. Y.
Yellott, J. L., Inst. of Gas Technology, 3300 Federal St., Chicago 16, Ill.
Ziebolz, H., Askania Regulator Co., 1603 S. Michigan Ave., Chicago 16, Ill.
Zucrow, Dr. M. J., Aerojet Engrg. Corp., 285 W. Colorado St., Pasadena, Calif.

DIVISION ASSOCIATES

Ahrendt, Wm., 545 Alden Ave., Westfield, N. J.
Barnett, H., Powers Regulator Co., 2776 Greenview Ave., Chicago, Ill.
Bosomworth, G. P., Firestone Tire and Rubber Co., Akron 17, Ohio
Brombacher, Dr. W. G., Bureau of Standards, Washington 25, D.C.
Brown, Dr. Gordon S., Servomechanisms Lab., Bldg. 32, M.I.T., Cambridge 39, M.I.T., Cambridge 39, Mass.
Cermak, Robert W., Dow Chemical Co., Midland, Mich.
Cloran, Everett, Pittsburgh Equitable Meter Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.
Cochran, J. K., Monongahela & West Penn Public Service Co., Fairmont, W. Va.
Cook, L., The Foxboro Co., Foxboro, Mass.
Dudley, Lieut. John W., Jr., U. S. Naval Experiment Station, Annapolis, Md.
Everhart, J. L., National Bureau of Standards, Washington 25, D.C.
Fairchild, C. O., C. J. Tagliabue Mfg. Co., 550 Park Ave., Brooklyn 5, N. Y.
Greaves, H. B., No. 1 Old Colony Lane, R. R. 13, Box 1684, Kirkwood 19, Mo.
Hammond, E. H., Manning, Maxwell and Moore, Inc., Bridgeport, Conn.
Harris, Herbert, Jr., 299 Jackson St., Hempstead, N. Y.
Hickes, W. F., The Foxboro Co., Foxboro, Mass.
Ivanoff, Dr. A., Hayward Tyler & Co., Ltd., Luton Beds, England
Johnson, S. P., Std. Oil Co. of Cal., San Francisco, Cal.
Kidd, W. H., The Foxboro Co., Foxboro, Mass.
Mason, C. E., Mason-Neilan Regulator Co., 1090 Adams St., Boston, Mass.
McCoy, W. K., Construction Div., Petroleum Adm., Interior Bldg., Room 2345, Washington, D.C.
Moore, Prof. A. D., College of Engrg., Univ. of Michigan, Ann Arbor, Mich.
Moore, Coleman B., Moore Products Co., H & Lycoming Sts., Phila. 24, Pa.
Nichols, Nathaniel B., Radiation Lab., M.I.T., Cambridge, Mass.
Rockwell, Ralph A., Mason-Neilan Regulator Co., 1190 Adams St., Boston, Mass.
Rolnick, Dr. H. A., 1748 N. Marvine St., Philadelphia, Pa .
Sipkin, George, Division 26, U. S. Patent Office, Richmond, Va.
Stover, Prof. E. F., Room 114, Engrg. Bldg., Univ. of Pennsylvania, Phila., Pa.
Summers, Prof. R. E., University of Minnesota, Minneapolis, Minn.
Swarr, J. N., The Bristol Co., Waterbury 19, Conn.
Sylvander, R. C., Pioneer Instrument Div., Bendix Aviation Corp., Teterboro, N. J.
Van der Pyl, Dr. Lyman, Pittsburgh 8, Pa.
Wheeler, H. E., M. W. Kellogg Co., 225 Broadway, New York, N. Y.
White, M. H., Atlantic Refining Co., 3144 Passyunk Ave., Phila. 45, Pa.
Ziegler, J. G., Taylor Instrument Companies, Rochester 1, N. Y.

COMMITTEES

Executive

Everett S. Lee, Chairman (1947)
J. C. Peters, Secretary (1948)
Ed S. Smith (1946)
E. D. Haigler (1945)
I. M. Stein (1944)

By-Laws

E. D. Haigler, Chairman

D. J. Bergman, A. A. Markson, J. B. McMahon, I. M. Stein.

Representatives on Special ASME Committee on Membership Development: R. L. Goetzenberger, R. E. Turner, L. M. K. Boelter.

Papers

P. W. Keppler, Chairman

G. W. Bosomworth, W. G. Brombacher, P. G. Exline, J. J. Grebe, E. D. Haigler, H. L. Mason, H. F. Moore, R. B. Smith, A. F. Sperry, R. D. Webb.

Terminology

H. F. Moore, Chairman

N. Belaef, D. P. Eckman, W. B. Heinz, J. B. McMahon, J. C. Peters, Ed S. Smith, H. E. Wheeler, J. I. Yellot, J. C. Ziegler.

Theory

A. F. Sperry, Chairman

Wm. Ahrendt, G. S. Brown, C. S. Draper, Herbert Harris, Jr., J. A. Hrones, Carl F. Kayan, C. E. Mason, N. B. Nichols, G. A. Philbrick, Ed S. Smith, G. W. Smith.

Design

W. G. Brombacher, Chairman

N. Belaef, G. P. Bosomworth, L. Cook, S. G. Eskin, J. L. Everhart, P. G. Exline, C. O. Fairchild, H. H. Gorrie, K. H. Hubbard, C. B. Irmer, A. A. Markson, C. B. Moore, J. N. Swarr, J. N. Swarr, R. C. Sylvander, H. Ziebolz.

Application

J. J. Grebe, Chairman

L. G. Bean, M. F. Behar, D. J. Bergman, R. W. Cermak, J. K. Cochran, J. W. Dudley, Jr., Paul Graff, H. B. Greaves, E. D. Haigler, J. H. Harlow, W. B. Heinz, E. J. Kohn, W. K. McCoy, R. B. Smith, R. D. Webb, H. E. Wheeler, M. H. White, M. J. Zucrow.

Bibliography and Translations

H. L. Mason, Chairman

S. G. Eskin, P. G. Exline, W. F. Hickes, G. H. Lee, L. Van der Pyl, H. Zieboltz.

LIAISON REPRESENTATIVES

C. O. Fairchild — American Institute of Physics
J. J. Grebe—American Institute of Chemical Engineers
E. S. Lee—AIEE Committee on Instruments and Measurements
Ed S. Smith—Aviation Division
R. B. Smith—ASME Committee No. 20 on Speed, Pressure and Temperature Responsive Devices
I. M. Stein—Gibson Island Conferences of AAAS.
A. Ivanoff—Institution of Mechanical Engineers (British)

This Annual Meeting's Activities of the IIRD

By ED S. SMITH, Research Engineer, Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

The writer was given this assignment not as a member of the IIRD's Executive Committee, but as an inveterate and confirmed writer who is a charter member both of the ASME's IIRD (CIIR) and of the New York Society for Measurement and Control, to "cover the IIRD sessions of the Sixty-third Annual ASME meeting in a chatty informal manner."

ON Sunday evening, November 28, all of the members of the IIRD's Executive Committee were present at the ASME's annual pre-meeting get-together at which the new officers and the rank-and-file of the Society's wheel-horses got better acquainted with one another's current problems.

It developed that Sam Lee, IIRD's Chairman, had been made the Chairman of the Engineering Council for Professional Development and feared that he might not be able, like former President Taft, to occupy two chairs simultaneously. Although the rest of the Executive Committee sympathized with his dilemma, they thought that this was his problem and refused to take official cognizance of his embarrassment unless or until he outright resigned. This position was reached after Mel Stein, who raised this new Division from a "Committee" and would have been drafted as Mr. Lee's successor, expressed his pleasure over Sam's persistence.

The other main point was Ed Haigler's tale of his 12-mile Hereford hunt in the wilds of Foxboro in which two wild and wily calves served as the "game," during which saga Secretary Peters ran out of cigars and started his annual lend-lease with this writer.

On Monday evening, the Executive Committee started its official meeting at dinner with the Chairmen of the IIRD's several Committees. Paul Keppler, on Papers, had really done a lot of work and it appeared that he still naïvely hoped to get some author to meet a dead-line at some Session in the coming year. Jerry McMahon, subbing for the Aruba-absent Harry Moore, on Terminology, stated in his round baritone that real progress has been made toward releasing for outside discussion some terms which the Terminology Committee deemed, after about five years of consideration, to be useful to process-application engineers, although possibly not ideal for automatic control generally. It was agreed that this should be given an early release as tentative.

Under the Leesian set-up:

Albert Sperry on *Theory* tackled the difficult job of making progress under wartime restrictions.

Dr. John Grebe, the current Chemical Medallist, had an easier task on *Applications* since there are many processes which, despite censorship, are still not unmentionable.

And Dr. Brombacher, of the Bureau of Standards, took on the development of an interesting series of papers on instrument and regulator *Design* enthusiastically but without illusions as to the amount of work involved.

Upon the Aviation Division's request for an Executive Committee Member of the IIRD who was also active in aviation, the writer was appointed liaison associate. Secretary Peters is tying in with other groups as to liaison, letting them know of the IIRD's activities and facilities. Later in the week Reg Pigott, Chairman of the Fluid Meters Committee and who supported from the start the IIRD and its parent CIIR, tied in with Secretary Peters so that the writer, who in times past had worked long on the FMC, could take care of the liaison-task.

Although the IIRD's tentative bylaws closely followed those of other ASME Divisions, McMahon allowed that they didn't meet the democratic ideal of a town meeting and a Bylaws Committee, including McMahon, was set up.

Chairman Lee's hard work on organization was rewarded by the relatively few changes suggested and by the smoothness with which the activities proceeded on Tuesday.

The sense of the meeting was that this group's activities were to be non-restrictive as to instrument activity of other groups and coöperative therewith, including with the various instrument societies throughout the country, following a policy of liberal liaison through men who as far as possible are members of the IIRD.

On Tuesday morning the several Committees met and enjoyed the confusion resulting from the expansion to include engineers from outside the Process Industries Division. In "Theory," the "servo-mechanism" group, of which Prof. Gordon S. Brown (M.I.T.) is senior member, was interested to find that they and the older group on "automatic control" could understand each other and speak in the common language of control. Dr. Grebe and his Applications Committee found plenty to do. Dr. Brombacher had the hardest job since his group had no nucleus of members who were used to working together but made a good start with the loyal support of his former Bureau colleague, Owen Fairchild.

At the luncheon, Chairman Lee gave the whole group an account of what had been accomplished since the preceding annual meeting.

On Tuesday afternoon, the Aviation Division and the IIRD enjoyed a joint technical session at which John Marchant, of Pratt & Whitney Aircraft, and the writer, of Eclipse-Pioneer, respectively acted as Recorder and Chairman with an attendance of over 150. Jerry McMahon reported on terminology and a surprisingly harmonious discussion followed.

A paper on Radiation Pyrometry in Supercharging Testing was given by V. P. Head of the G.E. Co., a high-light being that temperatures were responsively and accurately measured below 300°F. In the discussion, Mal Behar mentioned measuring sub-zero temperatures by a reversed radiation method and described a monomolecular-layer "receiver" as the low-lag ideal.

After a getting-acquainted-better, or 7th-inning, recess, Mel Stein read a paper on a high-speed multi-point potentiometer for recording temperatures on flight-testing planes. A. J. Williams, Jr. and W. R. Clark, his co-authors and colleagues at Leeds & Northrup, joined him in answering a lively discussion and in demonstrating the instrument which was on rockers.

Supper was started harmoniously with "Hi Lee, hi low" when Sam Lee appeared briefly to turn over the group to Secretary Peters. Don Bergman and Prof. Boelter joined the writer (all University of California men) at the "head table." At the end of the meeting, Chairman Lee returned to speak again.

In the evening symposium of the IIRD on the wartime problems of industrial-instrument departments, Don Bergman (& G. G. Gallagher) told of instrument maintenance of aviation gasoline plants, Bosomworth of instrument personnel difficulties, Cermak of training men for magnesium and styrene plants, Ted Cohen of material-substitution difficulties for wartime instruments, Geo. Martin (for H. F. Moore and W. C. Ludi) gave some experiences in starting process units, and R. D. Webb of piping and fitting difficulties for industrial instruments. Lee again acted as Chairman and kept the lively discussion within bounds although Jerry McMahon's voice was again raised in questioning the terminology used by the different speakers.

This lively meeting had such a large attendance that it was forced to shift to a larger hall. Altogether there was much evidence that it had been a wise move to form a Division which opened this group's activity beyond the bounds of the Process Industries Division.

election of Papers Presented at Sixty-third Annual A.S.M.E. Meeting

he first six papers (pages 7-18 incl.) y five users and one manufacturer of ndustrial instruments, are those preented at the symposium on instrument ngineers' Wartime Problems held Tuesay evening Nov. 30. For nearly a year, I&RD Program Committee Chairman aul Keppler (The Foxboro Co.) had worked to make this symposium session a success. Attendance was so large that the overflow jammed the Pennsylvania Hotel mezzanine balcony and forced moving from the assigned "parlor" to a fortunately-vacant banquet room. Interest had been intensified by rumor that the six papers would not be published anywhere. Basis of rumor may have been decision that they would not be printed in A.S.M.E. publications. All six are here printed in full.

Of the other papers (pages 19-58 incl.) two are printed in full, seven as "extended abstracts" with illustrations, all others in brief abstract form.

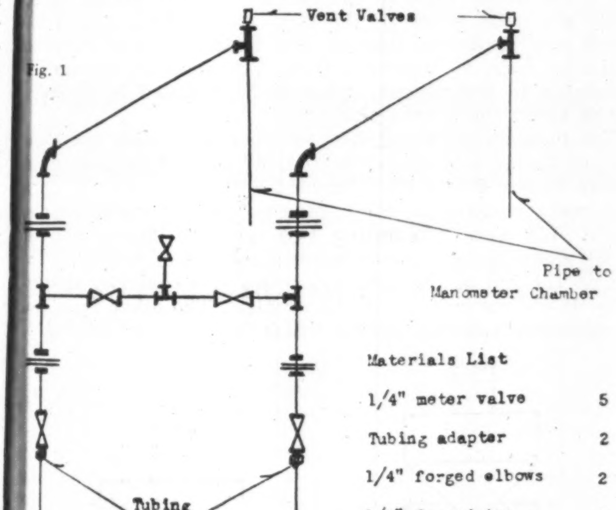
nstrument Piping, Tubing and Fittings During Wartime

By RALPH D. WEBB, Head, Instrument Department, Carbide & Carbon Chemicals Corp., South Charleston, W. Va.

RATHER than have me try to tell you how to meet the material shortages which have affected instrument piping and fittings, let me discuss what my organiation did to meet war conditions on the construction of its art of the synthetic rubber program. Even in 1940, before he inauguration of this program, we had begun to feel hese shortages and in 1941 we were gathering data, changng specifications and testing various hook-ups. This work rystallized and the blueprints showing the meter by-pass ssembly construction we devised were completed at a most pportune time: they were dated December 8, 1941. As you now, this was on Monday and on the following Saturday he first instrument engineering work on the "butadiene rom alcohol" plant began. This gave us a pretty good start.

With us, the basic instrument is the differential-pressure age. As a recorder it is the orifice meter; with a control echanism it becomes the flow controller which is so necesary to steady operation. It is used to indicate, record and ontrol liquid level, pressure drop, liquid specific gravity, nd pressures within a pound or two of atmospheric.

ig. 1



Materials List

1/4" meter valve	5
Tubing adapter	2
1/4" forged elbows	2
1/4" forged tee	5
1/4" vent valves	2
1/4" steel unions	4
1/4" steel nipples	16
Total forged fittings	16

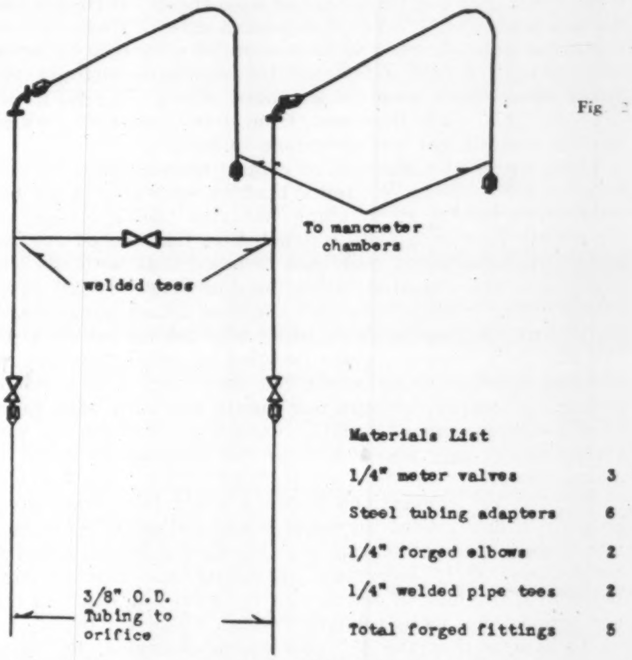
Each of these instruments requires a by-pass assembly t its manometer, and a pair of pressure leads from the byass assembly to the orifice or to the vessel where the presure differential is being measured.

Fig. 1 diagrammatically shows our pre-war by-pass asembly which consisted of five forged steel valves, four steel nions, and a considerable number of forged steel tees and ells. It represents the culmination of years: ample unions for easy assembly or for removal for manometer inspection, the five-valve by-pass, and forged steel fittings for strength.

We were able to work this over and reduce the number of valves from five to three, reduce the tees and ells to two and eliminate all unions. Fig. 2 will show you how this final assembly looked.

Note that we resorted to welded tees and that the unions were replaced by tubing fittings. A high percent of our differential-pressure instruments being of the mercury manometer type, we deemed it essential to use steel fittings and steel tubing to prevent the possibility of mercury amalgamation and consequent destruction of our fittings. Several brands of steel fittings were on the market but were difficult to procure; consequently, we bought the necessary equipment and had a sub-constractor make the standard SAE 45° flared fitting for us, using a mild steel hex stock afterward Parkerized for better corrosion resistance. The steel tubing employed was the same we used on the leads, the handling of which I will cover later.

Fig



Materials List

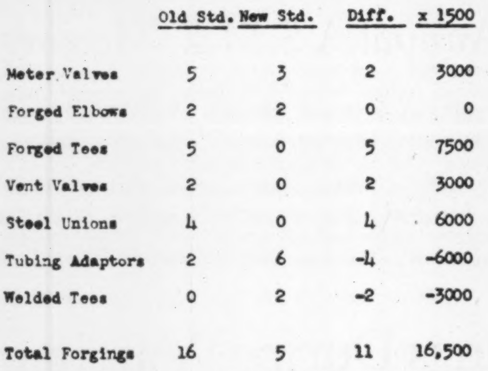
1/4" meter valves	3
Steel tubing adapters	6
1/4" forged elbows	2
1/4" welded pipe tees	2
Total forged fittings	5

The decision to go to the three-valve by-pass assembly was a hard one for us to make. For twenty years we had been using the Fig. 1 five-valve by-pass: two shut-off valves on the leads, two block valves and a bleeder between on the by-pass. We had worked extensively with meter valve manufacturers and had found several valves that could be trusted to give tight shut-off. The need to save critical forged pieces justified our taking this chance of a leaking by-pass.

It usually is desirable to incorporate in the by-pass assembly a means of releasing pressure. We felt that the ease with which one of the flared joints could be broken would permit its being used for pressure release, or, in the

---

FULL TEXT of paper presented at Annual Meeting of A.S.M.E., ew York, Nov. 28-Dec. 3, 1943, under auspices of Industrial nstruments and Regulators Division.



	Old Std.	New Std.	Diff.	x 1500
Meter Valves	5	3	2	3000
Forged Elbows	2	2	0	0
Forged Tees	5	0	5	7500
Vent Valves	2	0	2	3000
Steel Unions	4	0	4	6000
Tubing Adaptors	2	6	-4	-6000
Welded Tees	0	2	-2	-3000
Total Forgings	16	5	11	16,500

Fig. 3. Net saving of 11 × 1500 = 16,500 forgings.

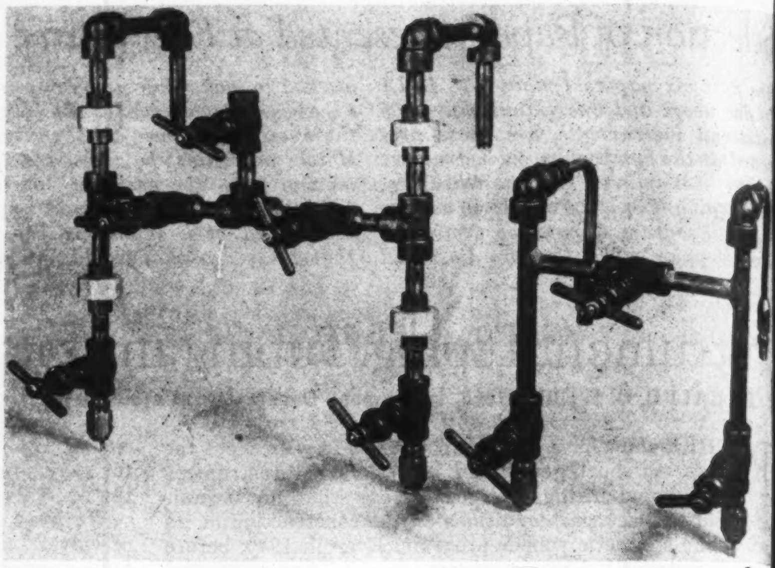


Fig. 4. The old five-valve assembly and the new three-valve assembly.

case of liquid-filled leads, for venting air bubbles from the high spot. This has proved practical in operation.

Fig. 3 tabulates the materials used in the old and new and shows the savings involved in the 1500 assemblies in use.

Fig. 4, a photograph of these two assemblies, gives an idea of their appearance.

For instrument leads we had previously used heavy-walled copper tubing, that is, a tubing with walls about 0.06″ thick. For dry leads we had used the ⅜″ O.D. size and for wet leads the ½″ O.D. We checked carefully over manufacturing data sheets and then assured ourselves by actually testing the tubing fastened between flared fittings. We found that there was an adequate safety margin if we dropped this wall thickness from 0.06″ to 0.03″, which change roughly cut our poundage in half.

Then, under the stimulus of copper conservation, we ran tests on steel tubing. We found that we were able to get not only plain carbon steel tubing but also tubing classed as tin-plated. Exposure tests conducted on the roof of our Instrument Department buildings revealed that both the tin-plated and the unplated tubing became deeply pitted after two months' exposure to our chemical plant atmosphere, forbidding the possibility of using this tubing out-of-doors. We did feel, however, quite justified in calling for its use indoors although doing so did not save such a tremendous amount of copper, because our plants are built with practically all equipment outside excepting instruments and compressors: only about 30% of the instrument leads indoors.

For the air connections between controllers and valves we had formerly used the same heavy-walled ⅜″ O.D. copper tubing, the justification for this having been somewhat as follows: Only two sizes of tubing and fittings were necessary, the bulk of which was ⅜″ size; and many of our air connections were relatively long. These conditions led us to believe that the ¼″ size was undesirable. By using the heavy-walled tubing we did not have to worry about the light tubing being installed on the high-pressure leads. War necessity led us to run some tests to assure ourselves as to the adequacy of its size, after which we adopted the ¼″ O.D. tubing for all instrument air connections. We started at the air header at the panel board and used it to the instrument and from the instrument to the valve. Also, we went from the air header to the valve positioner, but, in most cases, this header was out in the structure and so was rather short. In a few exceptional cases, involving large valves which required fast movement, we deviated from this last procedure but these cases were so few that we permitted them to go in with the ¼″ tubing and made the changes later when the small tubing proved inadequate. Again we used steel tubing inside and copper tubing outside and, of course, used quite thin walls.

I might remark that the steel tubing we used on this instrument air service had a light copper plating on the inside and we have found little tendency for this tubing to rust and produce iron oxide dust.

The fittings we used on the ¼″ instrument air tubing were of the compression type; that is, the type with the small brass sleeve, or ferrule, such as is used on the gasoline lines of our automobiles. This fitting was adopted mainly because of its light weight which meant a low poundage of brass. Moreover, it is faster to use than is the flared type. As no flaring is required you may wonder why we did not use this same type of fitting for our pressure leads, but we felt that it was inferior in regard to tightness under high pressures and also we did not want to use the brass sleeve close to the mercury in the manometers.

We are quite proud of the fact—and I think it will interest you to know—that at the Butadiene and Styrene Plant we built at Institute, West Virginia, our change in standards in instrument piping alone resulted in the saving of about thirty tons of copper.

The problem of flaring steel tubing is a tougher one than that of flaring soft copper tubing. When we first gave steel tubing to our fitters they fumbled with it for several days and were positive in their reports that it could not be flared. We were attempting two types of flares, one of which consisted in the conventional method of merely opening up the end of the tube by means of a conically shaped plug. It did not quite solve the problem. The other type did. It employs a two-step system which is illustrated in Fig. 5.

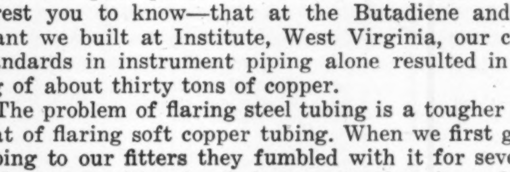


Fig. 5

The first step consists in placing a small piece (*a*) on the end of the conical plug and merely bulging the tube out as shown. The screw is then backed off, the piece removed, and the flaring completed as shown on the right. Note that the tube is not stressed at its cut end: we found that our per cent of splits was extremely low by this method whereas by the conventional method which did not fold back the metal, the tube split more than half the time. Incidentally, the little special piece (*a*) was developed by one of my fitters and I understand that he has applied for a patent on it. We found this flare very strong and, when used in the steel fittings, it gave us very little trouble from leakage. We did not use this type of flare with the copper tubing as it seemed unnecessary and, of course, was slower to make than was the simple flare.

The air distribution headers, which ran behind the panel boards and also out through the valves for positioner air supply, were changed from the old standard of brass pipe and fittings to galvanized.

All of these conservation measures have proved satisfactory in practice. The first unit started producing butadiene almost a year ago and today all the units are going at better than rated capacity.

Minimizing Instrument Maintenance in Designing Aviation Gasoline Plants

By DONALD J. BERGMAN and G. G. GALLAGHER, Universal Oil Products Co., Chicago, Ill.

SUCCESSFUL operation of the various processes used for production of the components of modern aviation gasoline depends in every case upon the accuracy and reliability of indicating and recording instruments and automatic control actuated from such equipment.

The following comments are based largely upon the engineering developed for instrumentation of a number of projects in the aviation gasoline program in this country.

QUALIFICATIONS OF PERSONNEL

In order to minimize the amount of labor spent in maintaining instruments and controls, the instrument man must, of course, know the details of the instruments on which he is working. Furthermore, he must know certain phases of the fundamentals and details of the various new processes in which the instruments are installed in order to appreciate the problems of an instrument and enable him to analyze the source of trouble in a complex control hookup. In general this calls for an instrument man of higher qualifications than commonly required in the past. To meet this condition it is necessary to conduct schools for the joint training of new operators and instrument personnel. Advantage should also be taken of the schools maintained by instrument manufacturers, usually at their factory headquarters, for further specialized training of instrument men. This is especially necessary in view of many new types of instruments being installed and developed, such as electronic type potentiometers, aneroid type flow meters, spectrographic analysis, etc.

GENERAL CONSIDERATIONS

In designing the processes, a special effort was made to stabilize each system as much as possible by the use of flow control, with adequate surge capacity between elements of the process where liquid level control was necessary. Such stabilization, by maintaining smooth operation and minimizing cycling, cuts down instrument maintenance.

An important factor in minimizing maintenance is the standardization of types of instruments and types and sizes of control valves, pressure gages, etc. This accomplishes two highly desirable results:

1. Reduction of necessary spare parts.
2. Reduction in the amount of training required for instrument maintenance men.

Equally important are a number of other features which are often given little consideration, such as the following:

1. Provision of a well designed and engineered cleaning and dehydrating system on the instrument air supply. Elimination of freezing and plugging of pilot valves and air lines, especially during winter weather, should cut the average plant instrument maintenance by at least 50%.
2. Accessibility of instruments and control valves. An accessible instrument will be quickly corrected, whereas one poorly located may be left for the morrow.
3. Provision of cooling fins on hot control valve bonnets will reduce packing troubles.
4. Valve positioners contribute materially to smooth control where sticking is encountered. Valve sticking is often erroneously blamed on the control instrument.

NEW PROBLEMS

Hydrogen Fluoride Alkylation.—Some of the processes used in the various aviation gasoline projects have brought new problems for the instrument maintenance man. The hydrogen fluoride alkylation process required development of a new technique for handling anhydrous HF and mixtures of acid and hydrocarbons at pressures and temperatures generally outside of those used in the previous handling of HF.

In view of the toxicity of HF and the corrosion products which cause sticking of close-fitted moving parts, it was decided that instruments should be bottle-tight and that pressure-tight bearings would be unsuitable. Accordingly, torsion tube transmissions were selected for flow and liquid level instruments. After such preliminary selections various types of valves, instruments, etc., were tested under conditions simulating actual service to prove stability. Wherever possible standard equipment was used to keep from interfering with manufacturers' production schedules.

In plant operation, knowledge and control of liquid levels is highly important. Since gage glasses are not usable in the presence of HF, displacement type float and differential type instruments have been provided to check each other. In field operation it has been found that the use of needle valve try-cocks, with proper precautions, is not as hazardous as at first believed. Observation of the material issuing from the try-cock distinguishes sharply between gas, hydrocarbon, and HF. This serves as a valuable occasional visual check on the instruments.

It is difficult and hazardous to pack control valves to hold HF and, since suitable packless control valves have not been available, a hydrocarbon purge system has been employed in conjunction with slightly modified standard valves using a lantern gland. The packing, therefore, does not come in contact with the acid.

Control valve material specifications play an important part. Monel or 18-8 stems, plugs and guide bushings minimize valve sticking. Carbon steel is fairly satisfactory where adequate clearance is provided, but the 14 chrome stainless steels commonly used as a standard oil-refinery service trim are unsatisfactory because of excessive corrosion and sticking.

In order to reduce hazard and maintenance problems, an exhaust system was provided which can be connected at convenient points to evacuate lines before breaking into them.

Isomerization.—Isomerization plants using combinations of aluminum chloride, HCl and hydrocarbons present a series of problems to the instrument maintenance man comparable to those in HF alkylation plants in connection with sticking and corrosion. Provisions similar to those in the alkylation plants are being used to minimize difficulties.

Fluid Catalytic Cracking Units.—In the fluid catalytic units, the principal problem was the measurement of pressure, flow and level of mixtures of catalyst dust with oil, oil vapors, air or gas. Purge connections between instruments and connecting taps through which a small stream of air or oil will flow to prevent catalyst from being carried into the instrument lines are used extensively. Measurements of flow in large lines where pressure drop would be

---

FULL TEXT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Industrial Instruments and Regulators Division.

undesirable are made by the use of air speed nozzles similar to those used on aeroplanes.

WARTIME CONDITIONS AFFECTING MAINTENANCE

In the early days of the aviation gasoline program, orders by the War Production Board for the conservation of critical materials, especially chromium and nickel, limited the use of these materials as trim in control valves, safety valves, etc., except under special conditions. As oil-refinery standards had generally been set up using stainless steels as standard trim, this necessitated making a given type valve with several alternate trims. This cut down on standardization and contributed to extended deliveries.

More recent orders relaxing the earlier requirements have recognized the fact that production is more important than conservation of the small amounts of critical material required for trim. However, many valves with substituted trims have been delivered on the jobs and will no doubt require replacement of the valve or trim in less time than would have been necessary had it been possible to follow the usual specifications.

Standardization of pressure gages at the order of the War Production Board has reduced the number of types available, minimizing spares required. An overall decreas in maintenance should result where a better class gage i used in a wider range of services.

Recommendations by PAW to use manually-operable con trol valves to eliminate the use of full by-passes and block will have a far-reaching effect on plant operation an maintenance. These recommendations were adopted widel by industry, in order to assist in reducing the overload o valve manufacturers. It is probable that within a reason ably short period of operation many such control valve will be fully fitted with by-passes after shutdowns cause by packing or stem failures have been encountered.

Preferred instrument and valve suppliers were overload ed with orders, due to the wartime demand, hence it wa necessary through governmental directives to distribute th demand sufficiently to make use of available capacities i other companies. This has resulted in some lack of stand ardization.

The burden on a limited instrument maintenance de partment can be cut down by consideration of the foregoing points during design and construction of new plants a well as by the provision of adequate spares and a properly trained personnel.

Problems in Obtaining Personnel in the Wartime Operation of an Instrument Department

By G. P. BOSOMWORTH, Head, Instrument Division, Firestone Tire & Rubber Co., Akron, Ohio

THE present type of warfare demands a considerable amount of mechanical knowledge from the personnel of the Armed Forces. In particular, the use of instruments has created a demand for men trained in their servicing and operation. It is, therefore, becoming to some extent a tug-of-war between the Armed Forces and industry to obtain experienced instrument men. Naturally, both have had to inaugurate training courses designed to provide the necessary skilled help.

The rapid expansion of industrial plants, and the creation of new plants for new products have further complicated the personnel problem.

In pre-war days the sources of instrument mechanics were generally other skilled trades, particularly pipe-fitters, stationary engineers and tool-makers. Today, men with this background are not available. The rubber industry was no exception with regard to the scarcity of skilled help for instrument service. It became evident in the early part of 1942 that a program would be required which would furnish men to supplement those engaged in this type of work. An investigation of the possibility of employing women in instrument calibration, repair and maintenance was begun, together with a revision in what we considered the minimum requirements in knowledge or experience necessary before either a man or a woman could be accepted for this type of work.

The men available for this training had to be selected from unskilled labor or unrelated trades, such as:

- Production workers
- Typewriter repairmen
- Musical instrument repairmen
- Laborers
- Watchmakers
- Automobile mechanics
- Plumbers' helpers
- Salesmen
- Service men for stokers
- Domestic refrigerator service men
- Timekeepers
- Utility meter readers
- Railroad brakemen

The training period lasted for six weeks, during which time the employee attended a class for four hours, and worked in the factory with an experienced man for th other four hours. A collection of representative instrument cycle controllers and valves was gathered and set up i such a way that calibration, operation and trouble shoot ing could be demonstrated. It was found necessary, in mos cases, to teach these men the names of pipe and coppe tube fittings. The training included rules on safety, an throughout emphasized the thought that maintenance shoul not be a policy of temporary expedience.

Facts on the available factory services and pressures, o other characteristics, were given. The trainee was instructe in the method of approach to a problem in maintenance so that he did not over-extend his limited knowledge by th hunt-and-peck system of trouble-shooting. It is realized, o course, that the training of any instrument man to handl any of the normal situations which arise in such wor requires two or three years and that to condense this int a short period of a few weeks is impossible. However, i was believed that with a nucleus of experienced men, th situation could be met in large part. There was available a limited number of men who had been hired before Decem ber 1941, who were learning the trade in the normal man ner, and we relied on these men as a further support fo the operation of the Instrument Division. It was foun that 50% of the men hired as trainees were both desirou of continuing in the work and able to make progress i acquiring the necessary knowledge. About 15% of th trainees hired have been able to extend their knowledg in a period of 15 months, to cover the complete instrume tation in some of the newer plants. These men can b classified as experienced. By an experienced instrume man is meant one who not only understands the instr ments but also understands the processes on which th are used.

Further expansion of manufacturing facilities created a increasing need for new personnel. This was accentuat by the further demands of the Armed Forces, who foun it necessary to take some of the newly trained men. I was then decided that women would be hired for trainin in some phases of instrumentation. Changing recording i strument charts is handled in part by women. Watc makers engaged in precision instrument work were au mented by the training of women. The calibration of pr sure gages and temperature recorders, and repair of di

---

FULL TEXT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Industrial Instruments and Regulators Division.

micrometers, were taken over in a large degree by female help. As these women obtained skill in the use of instruments and small tools, it was found possible to train them in the repair and reconditioning of cycle controllers, dial micrometers, thickness gages and time clocks.

The selection of female help was made from:

Grocery clerks
Punch press operators
Dairy Laboratory assistants
Department store clerks
Recent high school graduates with no experience

With the rearrangement of some of the work in the department, providing special jobs for those with limited knowledge and experience, with the use of women for some of the jobs requiring manipulative skill, with the spreading of the skilled help among the unskilled, it has been possible to operate without too many objections from the departments depending upon the services of the Instrument Division.

From our experience to date, it would seem that the training period for instrument work can be speeded up only if we limit the scope or the range of work required from a trainee of the instrument personnel.

We planned our training program to meet the exigencies of the emergency. While many new angles and possibilities have come to light, we believe that the condensed training period would not be advisable as a substitute for the normal course in peace-time conditions.

Training Instrument Men for the Government Magnesium and Styrene Plants

By ROBERT W. CERMAK, Instrument Engineer, The Dow Chemical Co., Midland, Mich.

IN early 1942, The Dow Chemical Company was faced with the necessity of procuring and training men to act in a supervisory capacity over instrument departments at the several government-sponsored magnesium and styrene plants projected at that time.

Magnesium is much in demand for aircraft castings, forgings, extruded shapes and incendiaries. New plants for additional production were being designed for Velasco, Texas, and Ludington and Marysville, Michigan.

Styrene, on the other hand, is one of the two major components which are used in the manufacture of "Buna S" synthetic rubber. Plants for additional styrene capacity were being designed for Torrance, near Los Angeles, California; Velasco, Texas, adjacent to the magnesium plant previously mentioned; with a third plant for the Canadian government at Sarnia, Ontario.

Since the processes used in both the magnesium and styrene plants were essentially continuous, it follows that a large number of automatic control instruments were incorporated in their design, to facilitate operation, keep operating personnel at a minimum and to insure correct specifications for the final product. As far as possible standard types of instruments were used, but in several cases at least, it was necessary to use special instruments and controls, previously developed by Dow for similar plants at Midland. Because of the number and complexity of the instruments and the close interconnection between instruments and proper plant operation, it was felt that technically trained personnel for the instrument departments was practically a necessity, particularly in view of the relatively short time available for training this personnel. Also, because of the size of several of the plants, it was felt that two technical men should be used instead of one. In these cases we tried to choose men whose training would supplement one another—a good combination for these plants we felt would be to have one man a mechanical or electrical engineer and the other a chemical engineer. At the same time a spirit of competition would exist and at some later date the more outstanding of the two men could be chosen to supervise the department.

For those plants where only one technical man was necessary, we were desirous of obtaining a man who had taken an engineering physics course or a course combining physics and electricity along with a reasonable amount of mathematics and chemistry; who had had some actual shop experience with ability to do drafting and some design work.

Also, as far as possible, we were looking for the inventive and ingenious type of individual, having the ability to do things with his hands whether it be to build some material object or shoot trouble on an electrical circuit.

The majority of men were selected by our technical personnel director after interviews with graduates at their respective colleges or universities — usually arranged through the college placement bureau. In other cases interviews were arranged with promising students on the recommendation of the department heads. Permanent record cards were usually examined beforehand to obtain information concerning subjects and scholastic standing.

However, not all our men were acquired in this manner. In one case, at least, an employee of a mid-western company, having read of our projected plants, contacted us requesting additional information. His application appeared sufficiently promising that an interview was arranged and the man subsequently hired. Previous flowmeter training which this man had had, plus his industrial experience, gave him considerable advantage over the rest of the trainee group. Two of our plants were located in Texas and, since we were quite aware of the motto "Texas for the Texans," men for the several plants were chosen, as far as practicable, from the section or locality in which the plants were being built. In this way, no great change in environment would be necessitated, except for the training period at Midland, and the men would be more satisfied and we felt more permanent in their new positions.

As a final confirmation, each man was interviewed on his arrival in Midland by the head of the Process Instrument Department, before a definite training course was assigned. However, our initial selection had been sufficiently careful that no changes were indicated at this point.

The acquaint the new men thoroughly with such things as shop methods and practice, shop organization, the handling of men, employer-employee relations, laboratory analysis, pilot plant operation and general plant maintenance, all men were put through a general training course which covered approximately sixteen weeks. This also gave us the opportunity to watch the men under actual working conditions and to obtain first-hand opinions of the supervisors under whom they worked. It was thus possible to spot a man's so-called "weak points" and to concentrate on them in order to turn out a well-rounded individual.

To this end, each of the trainees spent time in the Pipe, Boiler and Machine Shops; the Main and Physical Research Laboratories; and the Instrument Department. At the conclusion of each of the training periods, the student was required to hand in a written report which in some cases consisted of answers to a prescribed list of questions and in others of a fairly detailed write-up of the work done by him in that department. This report was carefully corrected and graded by the training supervisor who also graded the man on his character and ability. This information was forwarded to the Personnel Department for their permanent records.

The program herein outlined is an adaptation of a

FULL TEXT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Industrial Instruments and Regulators Division.

general student training course sponsored several years ago at Midland and which has been given either completely or in a modified form to all technical personnel hired since that time. The original program included a three-week period in the Instrument Department which was of necessity greatly increased since we were now interested in training instrument men.

Let us now take up the training in each of the departments in detail.

In the Pipe Shop each trainee spent some time with the shop superintendent learning the organization of the department, the classes of work encountered and how jobs of various types are handled. Several days were spent in the pipe stockroom to acquaint the student thoroughly with the various types of valves, pipe and fittings used in the plant. A week was spent in the shop proper where the trainee assisted the shop foreman and gained experience in handling men and the operation of shop equipment such as bending, threading and nipple machines and the various types of welding equipment.

To gain field experience, the man was next assigned to a fitter with whom he spent two weeks as a helper.

Training in the boiler shop was somewhat limited and consisted primarily of a study of gas and arc welding of steel and some of the more common alloys both in the shop and in the field. Additional experience was gained by assisting in the repair and retubing of one or more heat exchangers.

Two weeks' time was spent by the trainees in the Machine Shop. The first week of this period was spent as a machinist's helper doing field repair of various types of pumps, compressors and similar equipment. The first half of the second week was spent doing bench repair work in the shop. This usually consisted in helping disassemble and completely overhaul a centrifugal pump. The student was also required to prepare and to rebabbitt one or more bearings. The second half of the week was spent doing minor machine jobs on the lathe, drill-press or shaper.

In the Main Laboratory, the student became familiar with the various methods of control analysis commonly used in the particular plant to which he would be assigned. Actual plant control samples were given to the student for analysis and report. One or more complete distillations and gas analyses were made by the trainee to acquaint him thoroughly with the methods and equipment used in doing this type of control work.

At the time the training course was in progress, the Physical Research Laboratory was working on several minor improvements which it was felt would be advantageous to incorporate in the plants then under design. To insure that there would be no so-called "bugs," pilot plants had been set up in which these improvements could be tested under actual operating conditions. Since all major instruments and controls had been incorporated in these pilot plants, the trainees, while testing the new developments, obtained more first-hand information on the interconnection of instruments and process than could have been received any other way. The usual continuous chemical process presents an overwhelming array of stills, columns, heat exchangers and pumps with interconnecting piping which is almost hopeless to trace. Here was an operating plant in all its essentials in which one could readily study the effects of one control upon another and also upon the whole process in general. Each of the trainees spent approximately three weeks operating and studying these plants.

The remaining three weeks in the Physical Research Laboratory were divided between the electrometric laboratory and the laboratory drafting room.

In the electrometric laboratory, the trainees became familiar with the more highly specialized methods of chemical analysis such as electrometric titrations, polarographic analysis and electrical conductivity measurements. Instruction was also given on maintenance and servicing of several special instruments and controls which had been developed by this laboratory group primarily for these particular plants.

During the period in the drafting room, the students plotted graphs and made sketches for reports and worked on some current design problem, preferably one dealing with some new instrument or automatic control development.

At the completion of this preliminary training, the students were transferred to the Process Instrument Department and the remainder of the instruction was given either in this department or under its supervision.

Trainees were usually started on the gage repair bench where they repaired and recalibrated several pressure gages. From this the students graduated to the checking of recording thermometers, to the manufacture of thermocouples and finally to doing minor repairs and calibration of instruments brought into the shop.

To obtain first-hand experience on maintenance and repair of instruments in the field, the trainee was placed as a helper under the supervision of a maintenance route man. His work in this capacity was quite varied: it might consist in replacing a thermocouple or lead wire, replacing a filter or air reducer, assist in making major mechanical or electrical repairs to a recording potentiometer, flow controller, or the safety equipment on some gas-fired heating oven. Much of the student's instruction was obtained either by actually working with some particular instrument, verbally from the shop or field foreman or from the man for whom he was working. This instruction was supplemented by the department files which yielded catalogs, wiring diagrams and instruction bulletins for the more complicated systems.

The students' training seldom followed a prescribed course. The men were shifted from job to job in order to round out their experience as much as possible. The trainees as a whole assimilated information quickly enough so that in a relatively short time they could be depended on to do minor jobs alone, such as the installation of a recording thermometer or simple controller or the handling of a service call.

Instrument installation on construction jobs at Midland is handled somewhat differently from that in most other companies. Actual installation of instruments in a new plant, including setting up of the panel boards, mounting of instruments and the running of electrical conduits and piping and all testing, are done by an outside contractor. However, all work is supervised by and subject to the approval of the Instrument Department, which upon completion of construction prepares the instruments and controls for service and assists the operating personnel in placing the plant in operation.

We were extremely fortunate at this time in having under construction plants for additional styrene production capacity at Midland. This afforded the students an excellent opportunity to follow the actual construction of a plant from start to finish and gave them training which was extremely valuable later on when they were called upon to supervise instrument installation in the government plants.

Advantage at this time was also taken of the training courses offered by three of the instrument companies. Each of the courses covered a period of one week and included lectures on specific types of instruments with practical instruction on their maintenance and repair. The lectures were supplemented with demonstrations of actual instruments with which the students became familiar by being permitted to make adjustments and repairs. Instruction was also given the students in flow measurement (including orifice plate calculations), pyrometry, control valve design and the fundamentals of automatic control.

When the trainee group returned from their eastern trip the Midland plants were rapidly nearing completion and were soon ready to have the instruments prepared for service.

This work was done entirely by the students under the supervision of an experienced instrument man.

During the starting-up period, the students were placed on shifts in order to have one or more instrument men on duty at all times. Experienced men, however, were on call should an extremely unusual condition arise. The plants as a whole started up with no more than the usual amount of difficulty and with a minimum of assistance from the regular instrument department personnel.

By the time the Midland plants were operating smoothly, several of the government plants were far enough along in construction to require supervision of instrument installation. The instrument men for these new government plants were transferred immediately to their permanent locations. The remainder of the trainee group occupied their time by brushing up on certain phases of instrument work which were not quite clear, checking over flowsheets and blueprints of their respective plants, going over the equipment, tool and spare parts lists for their departments and checking on instrument deliveries. One group prepared the majority of their permanent instrument records before they left Midland while another made up detail drawings showing the instrument piping behind each of the panel boards with the location and method of supporting each of the instrument lines from the panel board to its connection into the process piping.

It has been my good fortune to assist in starting up several of the government plants and in each case I have found that the training of the instrument department personnel has been adequate to provide the necessary instrumentation to allow plant operation at or above design capacity and to produce a finished product meeting government specifications.

Some Experiences in Putting Recent Process Units Into Operation

By **H. F. MOORE** and **W. C. LUDI**, General Engineering Dept., Standard Oil Development Co., Elizabeth, N. J.

THE war efforts of the Petroleum Industry have, to a large extent, involved the use of processes which bring with them interesting and difficult problems in measurement and control. In the production of such war materials as Aviation Gasoline, Butadiene, Rubber and Toluene the processes have varied sufficiently from those of pre-war days as to demand, in many cases, a radically different approach in the application and operation of automatic control instruments.

CLOSE FRACTIONATION PROBLEM

In the production of the above materials, it is necessary to fractionate light hydrocarbons such as butanes, butenes, propylenes and ethylene. In producing these components we have the problem of fractionating and controlling hydrocarbon mixtures with very narrow boiling ranges and, therefore, with no appreciable temperature range for a particular pressure. During the operation of a recent plant it was necessary, to meet the requirements of purity of product, to control the pressure at the center of a 60-plate tower within 0.1 lb./in.^{2} at approximately 30 lbs./in.^{2} gage. A temperature control point was also included at the same point as the pressure and which reset a flow controller controlling the amount of product taken out of the reflux drum. A level controller was installed on the reflux drum controlling the rate of reflux to the tower. With this system the temperature at the center of the tower is being controlled indirectly by the rate of withdrawal from the unit. The tower pressure controller operated a control valve on the water outlet of the overhead condenser. The pressure instruments which were available incorporated pressure-responsive elements having a guaranteed accuracy of 0.5% of their range and with a sensitivity somewhat better than the accuracy but still not approaching the requirements. It can be seen that the commercial instruments available would not be suitable for the sensitivity and accuracy of pressure desired and, therefore, it became necessary to obtain instruments of a special nature. In the above case, an instrument using the pneumatic null balance system was obtained with a 10-lb. range, suppressed for the operating pressure. After the initial adjustments were made to the system, pressure records and product tests indicated the control was within 0.025 lbs. With the pressure controlled within such close limits the remainder of the controls on the unit operated very satisfactorily.

Since the operation of this pressure controller was the critical point in the successful operation of the plant, extreme care was taken in its installation and maintenance, and it was somewhat babied along until the desired character of operation was obtained. It became apparent in this installation that its instrument air must be free of dirt, oil and moisture. On this unit it was demonstrated on several occasions that hand control of any important process variable produced totally unsatisfactory results and, as a consequence, all major control instruments must function for satisfactory unit operation.

REFRIGERATION CONTROL

In addition to the problems in fractionating light hydrocarbons, some processes require large refrigeration systems. Many factors enter into the control of such a system, the first important factor being the operation of the level controllers in the coolers, some of which operate as low as −140 to −150°F. It was determined in a recent plant that neither the conventional external ball float nor the displacer type were suitable, due to excessive boiling in the chamber and lower balancing line. In the majority of cases where accurate and stable level control was necessary the differential type was finally installed. Many methods of installation were tried and it was finally determined that the most suitable method was to operate with dry legs on the manometer leads. This was accomplished by two methods: first, heating of lead lines by steam jacketing or steam tracing; second, use of a hot blowback gas, which constitutes the "bubble" system. The first method has the disadvantage of adding a considerable heat load to the system.

The second important factor in controlling a refrigeration system is the suction control of compressors. The experience recently obtained has been with gas-engine-driven compressors where the suction pressure is controlled by varying the speed of the compressors. This in all cases was accomplished by the installation of a diaphragm motor to vary the spring tension of the compressor governor. Much care should be taken in adjusting the diaphragm to the governor and to be sure that the governor is functioning smoothly and is free. In a recent plant a great deal of trouble was experienced with suction control and after much work the trouble was traced to the poor operation of the compressor governors which were of excellent design but during construction were left unprotected from the weather and had become rusted and filled with dirt.

TIE-IN OF BATCH EQUIPMENT

Certain of the newer process units involve the inclusion, in a primarily continuous process, of equipment which itself inherently must operate on the batch principle, being alternately shifted from "reaction" to "regeneration" or vice versa. In tying the batch equipment into the continuous process a fairly complex timing mechanism is employed, which utilizes cam-thrown switches to actuate the starters of motor-operated valves and to check, through alarm contacts on the valves, to insure proper operation of the valves.

FULL TEXT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Industrial Instruments and Regulators Division.

The use of cams is feasible for this job only because all valve operations occur during a limited time, thus allowing the cams to rotate rapidly a full 180° on each "transfer" portion of the cycle, and then stop completely during the much longer "normal operation" portion of the cycle. For this service timing accuracy of one second was desired. Four-inch cams and mercury bottle switches were built into the timer. It was quickly determined, on starting the process unit, that the one-second accuracy was not obtainable, and dependability was poor. By recutting the cams to get the fastest possible switch operation it was possible to use the timer, but only by allowing more than a desirable time tolerance in the alarm and check circuits. With 4" cams it was definitely determined that mercury bottle switches could not time to one or even two seconds. As changing cam size would have meant a completely new timer, the 4" cams were retained and the switches changed to the spring-finger open-contact type. These allow timing to the one second originally stipulated.

RUBBER PLANT PROBLEM

In the production of rubber, several difficult problems arise. The most interesting is the handling of liquid streams containing small rubber-like particles after the reaction has taken place. In one particular case where the flow was controlled, Venturi tubes were used as the measuring element. On the lead lines to the manometer a suitable wash-back was installed to keep them free of the rubber particles or latex. The design of the control valves installed in the lines handling the rubber particles in slurry form was somewhat special. The valves used were basically the angle Venturi type with the plug modified so that it was in the form of a cylinder plug, with the side of the plug facing upstream tapered off so that the opening dimensions would be as large as possible for all port areas, thus allowing the particles to pass, instead of being "strained out," with consequent plugging. In order to prevent sticking in the guides, flushing connections were installed which kept all rubber formation from accumulating at these points. In the manufacture of aviation gasoline, similar valves were required to handle a slurry of oil and small granular particles. In this case control valves were used in a known troublesome service with high-pressure drops and a severe erosion problem, to get around the use of more than one pump in the slurry service. It would be possible to eliminate the slurry valves by having a turbine-driven pump in each line and controlling turbine speed, but it was felt that a properly-designed valve would require less maintenance than a pump in such a service.

PERSONNEL SERVICE

Today more than ever before, trouble is being experienced in the refineries due to lack of sufficient trained instrument personnel. With the sudden increase in construction, it has been necessary for the instrument departments of the refineries to spread their better instrument men over a wider area, thereby reducing their effectiveness. Many of the instrument groups have lost a large number of their first and second class men to the Armed Forces, which loss was made up with men obtained either from the outside or brought up through the ranks. These replacements for the most part are untrained and inexperienced in the basic principles of instrumentation. Consequently, the instrumentation within the plant itself, being greatly expanded, is considerably hampered by the inability of the instrument men to cope simply with the maintenance of the instruments—to say nothing of the instrument problems brought on by the new process requirements.

Thus, more than ever before, a good training program should be carried on. Without it, the inexperienced and untrained men have to obtain their information by the trial-and-error method which is long, expensive, and generally unsatisfactory. A good training program can be incorporated in an instrument department, and it must have as a

STARTING JANUARY 18TH

IT'S UP TO YOU!

STARTING January 18th, it's up to you to lead the men and women working in your plant to do themselves proud by helping to put over the 4th War Loan.

Your Government picks you for this job because you are better fitted than anyone else to know what your employees can and should do—and you're their natural leader. This time, your Government asks your plant to meet a definite quota—and to break it, *plenty!*

If your plant quota has not yet been set, get in touch now with your State Chairman of the War Finance Committee.

To meet your plant quota, will mean that you will have to hold your present Pay-Roll Deduction Plan payments at their peak figure—*and then get at least an average of one EXTRA $100 bond from every worker!*

That's where your leadership comes in—and the leadership of every one of your associates, from plant superintendent to foreman! It's your job to see that your fellow workers are sold the finest investment in the world. To see that they buy their share of tomorrow—of Victory!

That won't prove difficult, if you organize for it. Set up your own campaign right now—and don't aim for anything less than a 100% record in those *extra* $100 bonds!

And here's one last thought. Forget you ever heard of "10%" as a measure of a reasonable investment in War Bonds under the Pay-Roll Deduction Plan. Today, thousands of families that formerly depended upon a single wage earner now enjoy the earnings of several. In such cases, 10% or 15% represents but a paltry fraction of an investment which should reach 25%, 50%, or more!

Now then—Up and At Them!

***Keep Backing the Attack!*—WITH WAR BONDS**

This advertisement prepared under the auspices of the United States Treasury Department and the War Advertising Council

undation certain basic principles. The first principle to tablish is to see that the trainee has an opportunity to arn under good supervision, on equipment set aside for e purpose. A common mispractice is to attempt to demonrate on "live" equipment, which has a unit under control. second major point, which should need no mention; but hich is frequently overlooked, is to organize the material ith the simple maintenance problems and mechanical deils first, then gradually leading up to the control applicaons. With most training programs encountered thus far, e aims have been set far too high for the newcomer to the field. Until a reasonable background of experience is obtained there is little point to dwelling on the intricacies of application engineering. It is important, however, that each man be familiar with the operation of the particular unit on which he is expected to work. He should be given an engineering flow plan and the process described to him by flow rather than by the chemical aspects: if he absorbs the information given him from such a set of instructions, he will be better qualified to know what an instrument is expected to do and how it should function with the rest of the unit.

Wartime Material Economy in Instrument Design

By **THEODORE A. COHEN, Chief Engineer, Wheelco Instruments Co., Chicago, Illinois.**

DESIGNERS and manufacturers of scientific apparatus for industrial plants and laboratories have been faced with the necessity of finding replacement aterials for those items traditional to the industry which ere diverted to channels of armament manufacture.

In many cases, substitute materials, even when found atisfactory, had to be supplemented by improved design nd simplified manufacturing processes, chiefly to reduce an-hour requirements as labor was siphoned off from inustry to the Armed Services.

The imperative necessity of training raw and inexperinced labor has been a further incentive for simplification f manufacturing processes.

Like many others engaged in the complex manufacturing rts, the apparatus manufacturer has been required to nderstand the utilization, application and fabrication of a ost of new raw materials ranging from viscous organic lastics to hard-metal alloys. This has been especially true or those manufacturers of scientific apparatus who specialze in the fields of electrical measuring and control instruentation. Manufacturers of automatic control equipment n pyrometry, fluid flow, pressure, etc., have particularly elt the impact of the material dearth and, therefore, have een keenly concerned with problems of conversion in mateials and manufacturing processes.

It would be impractical in a short discussion of this ature to attempt to list the many possible substitute mateials and processes recently made available. Here are a ew examples:

a. Powder metallurgy
b. Hard glass jewels for instrument bearings in place of imported sapphires.
c. Beryllium copper for springs (eliminating the scarce tin phosphor bronzes)
d. Permanent-magnet alloys, especially in the Al - Co - Ni group.
e. Increased use of mass-production welding processes for die-cast aluminum.
sheet metal fabrication, replacing scarce sand-cast and
f. Plastic-base corrosion-resistant finishes.
g. Synthetic plastics with new properties.
h. Corrosion-resistant alloys with and without magnetic properties, using a minimum of scarce strategic materials.

Materials like these have eased the problems of the esign engineer, whose functions are to study substitute aterials and methods and to evaluate their relative advanages, to the end that the final product corresponds, in unction at least, to its corresponding peace-time product.

In the following discussion the author will restrict himelf to two random instances of the application of the ewer materials and processes: (1) permanent magnets nd (2) sheet metal fabrication.

I. The Newer Magnetic Alloys for Permanent-magnet Manufacture

In the apparatus industry, an important use for peranent magnets is to produce a fixed and uniform magnetic eld in such measuring instruments as voltmeters, ameters, pyrometers and the like, based upon the designs of d'Arsonval and Weston. Such an instrument for the measurement of minute d-c. voltages and currents is illustrated in Figs. 1, 2 and 3. An armature coil (*d*), usually consisting of a "former" carrying a number of turns of insulated copper wire, is swung upon hardened steel pivots rotating in jewel bearings (*i*), usually of sapphire, so that the coil itself rotates in an annular magnetic gap (*j*) in which by design there exists an even distribution of magnetic lines of force produced by a permanent magnet (*a*). The two spiral springs (*l*) not only conduct current to the armature coil but produce the forces required to restore the instrument to scale zero. Judicious design permits calibrating the scale in terms of current flow through or voltage across the armature coil. The system is essentially a limited-travel electric motor in which all the electric energy fed into the system produces a turning force which can be balanced by the tensioned spiral springs. The torque generated by the current flow through the armature is given by the primary relationship:

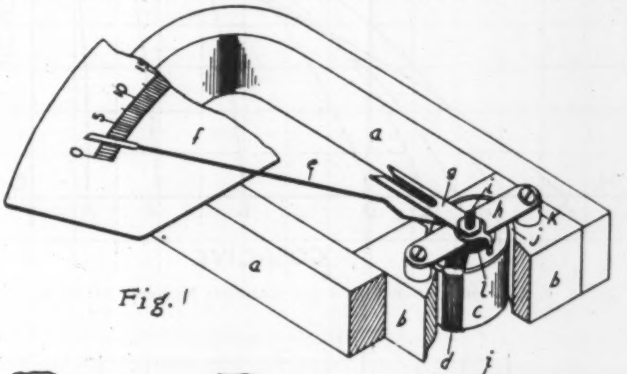


Fig. 1

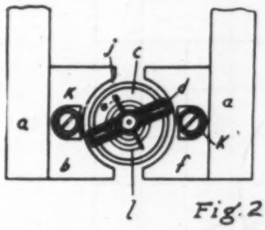


Fig. 2

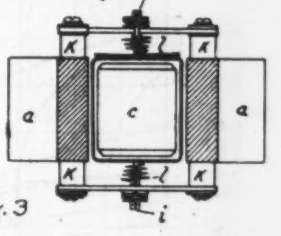


Fig. 3

$$\text{Torque in g.-cm.} = \frac{I\,T\,H\,A}{9810}$$

where I = current in amperes
T = turns
H = flux
A = area of average turn

A moment's study of this relationship brings out the dependence of the torque upon the magnetic lines of force in the annular gap—lines of force due to the permanent magnetic structure.

In studying new ferromagnetic alloys, some figure of merit must be evolved so that laboratory results may have quantitative significance for design purposes. To attain such a figure of merit, we select the magnetic character-

---

FULL TEXT of paper presented at Annual Meeting of A.S.M.E., ew York, Nov. 28-Dec. 3, 1943, under auspices of Industrial Intruments and Regulators Division.

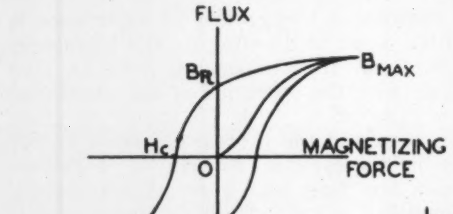


Fig. 4. Magnetization Curve.

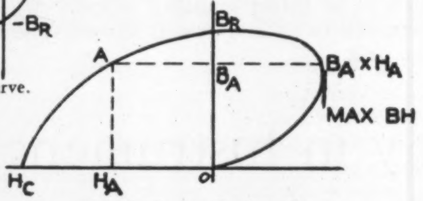


Fig. 5. Energy Product Curve.

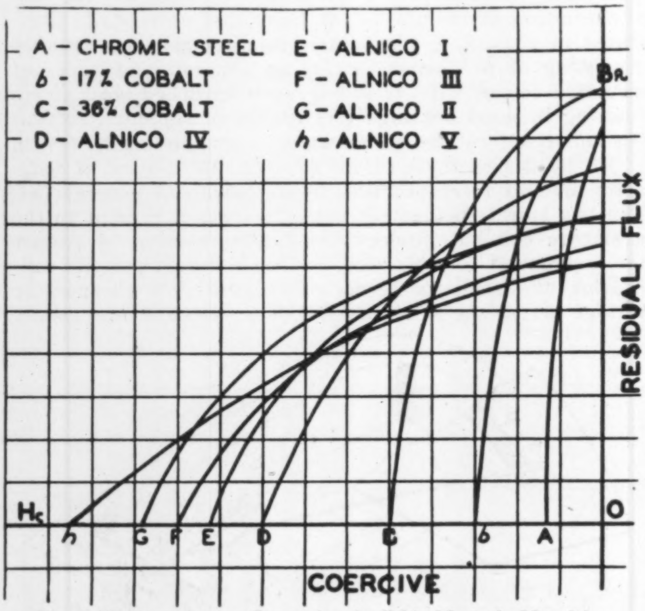


Fig. 6. Demagnetization Curves for Available Magnetic Materials.

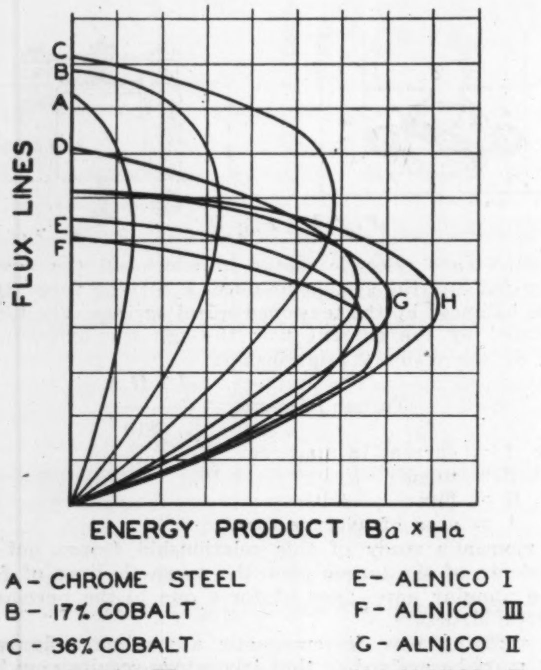


Fig. 7. Energy Product Curves.

istic which relates the induced magnetism within a given ferromagnetic material to the magnetizing force which induces this magnetism. Such a relationship is plotted in Fig. 4. On the vertical axis we have the induced magnetism, in magnetic flux per unit cross-sectional area, while the horizontal axis denotes the magnetomotive force. If an initially unmagnetized magnetic material is subjected to a gradually increasing magnetic field, the flux density in the material gradually increase along a curve such as 0 to B_{Max}. If the exciting magnetomotive force is then gradually reduced to 0, the flux density in the material decreases along a curve such as B_{Max} to B_R. This value B_R is the residual flux density or retentivity of the material which has been magnetized. If the magnetomotive force is reversed in direction and gradually increased in value, the flux density in the material is further reduced, reaching zero value when the value of the demagnetizing force is H_C. This value H_c is referred to as the coercive force.

Continuing to increase the negative magnetic intensity causes the flux density in the material to rise in the opposite direction along the curve H_C to $-B_{Max}$. Completion of the test cycle from this final negative value results in the curve $-B_{Max}$ to B_{Max}.

This entire closed curve (when it becomes really closed after a number of cycles) is referred to as the *B-H* characteristic or hysteresis loop or normal or symmetrical hysteresis curve. Its accurate determination is sometimes difficult; hundreds of scientific papers describe various instruments and methods, but suffice it to mention two pertinent facts: (1) This curve is a characteristic of all magnetic materials. (2) It varies enormously in shape and area with particular magnetic materials: those with small coercive force on demagnetization are known as "soft" magnetic materials and are useful in the design of equipment such as relays; those with high coercive force, which are capable of storing or retaining a large amount of magnetic flux after magnetizing forces are no longer present, are the "hard" magnetic materials chosen for permanent magnets.

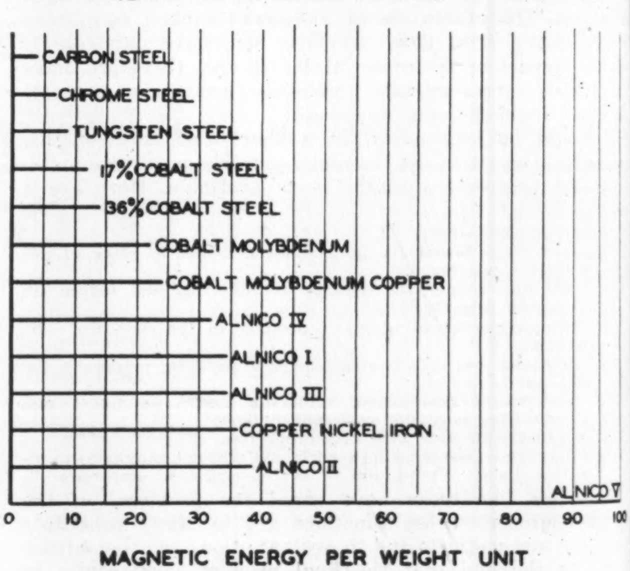


Fig. 8. Energy Value Comparison for Available Permanent Magnetic Materials.

Contents of —	Al	Co	Cu	Ni	Fe
Alnico I	11-13%	5-6%	2-3.5%	18-21%	Remainder
Alnico II	11-13	12-13	5.5-6.5	17-20	
Alnico III	11-13	0.5 max.	3-6	24-26	
Alnico IV	11-13	0.5-6.5	1.5-3	27.5-28.5	
Alnico V	7.5-9.5	24-26	3-6	14-16	

Fig. 9. Alnico Alloys

The most important information, concerning a permanent agnet's ability to produce a magnetic field, is the demagetizing section (B_R to H_C) of the *B-H* curve, for it may be sed to plot an acceptable index to the amount of magnetic nergy available in a permanent magnet by plotting a curve f the products of any two values of *B* and *H*. Such a urve is illustrated in Fig. 5 which was plotted from Fig. 4.

Many steels have been used in the past for instrument agnet manufacture, among them the chrome steels, tungsten steels and cobalt steels. None of these lends itself as eadily to improvements in instrument manufacture as do he recently-developed aluminum nickel steels referred to s the Alnico group. Fig. 6 is a family of coercive curves or the conventional magnet materials as compared to the lnico group. Note the higher coercives achieved by the ew materials.

Fig. 7 is a family of energy product curves plotted as reviously described from Fig. 6 and again indicates the igher energies of the Alnico group, especially in curves G and *H*. Alnico materials exhibit greater magnetic energy ontent per unit weight than any previous magnetic material used in instrument manufacture. Fig 8 is a comparative hart of the various magnetic materials as regards magnetic energy per unit weight. Approximate analyses of the lloy constitutents in the Alnico group are tabulated in Fig. 9.

The availability of Alnico materials has been a boon to nstrument designers desiring to effect material savings nd to minimize manufacturing process requirements. It as not only made possible weight reduction of the magnet system, but also economies in choosing of materials and esigning the structure of the remainder of the magnetic ircuit. This, in turn, has made possible the re-design of he *moving element* of the instrument and the simplification f processing problems with still further savings of labor n manufacture.

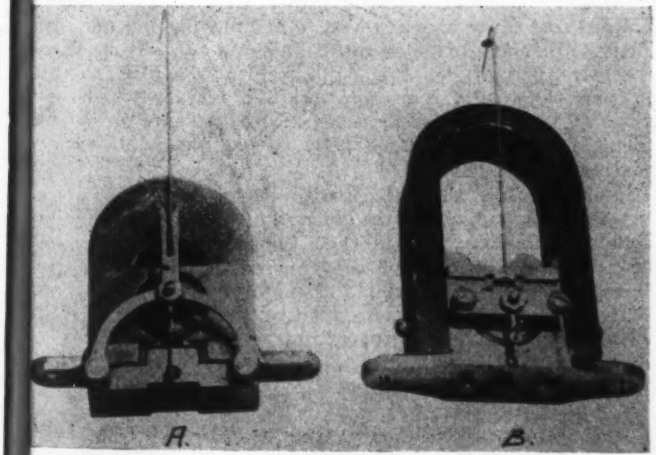


Fig. 10

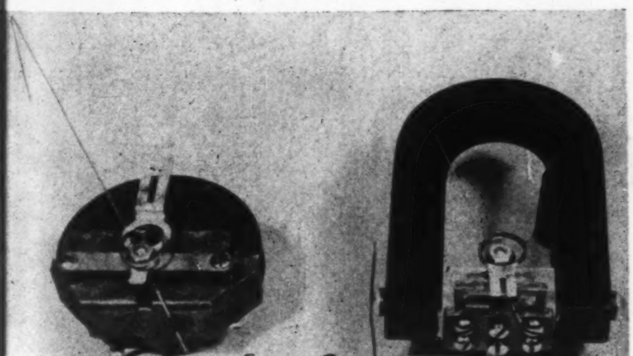


Fig. 11

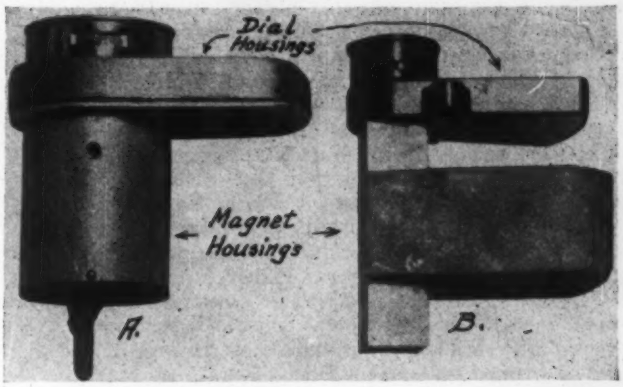


Fig. 12

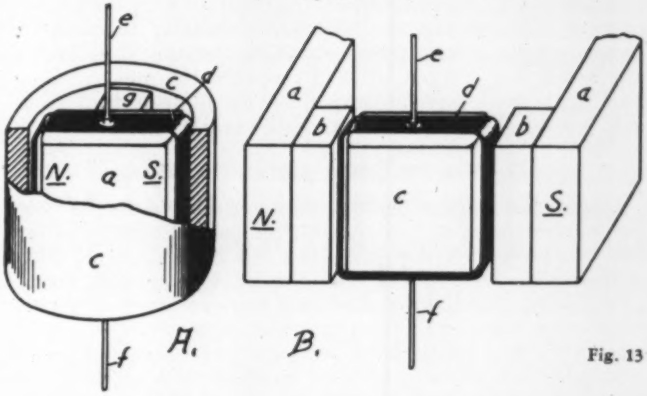


Fig. 13

Some Practical Results.—Three actual examples of design changes consequent to using some of the new magnetic materials have been selected as fairly typical. The illustrations are uniformly arranged, with the new design (*A*) at the left and the conventional design (*B*) at the right.

Best-known and most widely used type of electrical instrument is the medium-size medium-range d-c. measuring instrument. The conventional design shown at *B* in Fig. 10 will immediately be recognized. Its new design is shown at *A*. Note the difference in sizes and weights of the two devices. The improved magnet design allows the use of smaller amounts of required materials in the remainder of the instrument. The simplification is apparent and it is of interest to report that the newer design allows at least 20% improved measuring results in addition to large economies is labor processes.

Fig. 11 is a similar comparison of measuring instruments: at the right the conventional unit and at the left the redesigned unit using the new magnetic material. In addition to the many structural improvements which become apparent on examining the photograph, it can again be reported that the performance of the new model is far better than that of the old.

The final example is a galvanometer. Fig. 12*B* shows the conventional design. Note the familiar large magnet assembly. The redesigned unit shown at *A* makes use of high coercive permanent-magnet materials with consequent economies in space, weight, secondary materials and manufacturing time. Fig. 13 compares cross-sectional views of the conventional (*B*) and the improved (*A*) galvanometer designs and requires a few words of explanation. Note first, in view *B*, the conventional armature coil (*d*) swung in the magnetic gap between core block (*c*) and pole pieces (*b*) of magnet (*a*). In the improved design (*A*) a miniature magnet (*a*) of the Alnico group is mounted upon nonmagnetic blocks (*g*) within the soft iron cylinder (*c*), completing the magnetic circuit and leaving a gap within which is swung the armature coil (*d*). In addition to the savings in materials, weight, space and labor—which are fairly apparent—the new design has accomplished a considerable increase in sensitivity, which is of course the characteristic wanted in a galvanometer. A war-time requirement, however, was that higher sensitivity should not be attained by the sacrifice of ruggedness. This is not the occasion for a detailed technical explanation of how greater ruggedness was achieved together with higher sensitivity, but professional designers will see the possibilities when they carefully examine Fig. 13. In brief, the new galvanometers have not only a much greater torque-weight ratio but the proportions are such that the effects of shocks and severe vibrations can be taken care of more easily.

All in all, these new designs have not only effected economies in instrument manufacture, but they exhibit improved measuring properties: higher torques and sensitivities, reduced friction and similar electrical improvements, together with the mechanical endurance demanded by the Armed Forces and by war industries because of the shortage of trained instrument repairmen.

The fundamental significance of these redesigns of d-c. instruments is that the most frightful war in which our country has ever been plunged has stimulated the creative resourcefulness of American electrical-instrument designing engineers to bring out after fifty years the inherent abilities of the basic permanent-magnet moving-coil design created by Arsène d'Arsonval and Edward Weston.

II—WELDED SHEET METAL HOUSINGS

One of the more pressing wartime problems confronting the manufacturer of instruments and control apparatus has been the procurement of large and small housings and other parts which were formerly of die-cast or sand-cast aluminum. When aluminum restrictions were imposed, the manufacturers had to find substitute materials even if his costs were increased. Zinc base castings which entailed small conversion of die and pattern equipment were tried and found to be unsatisfactory from the standpoint of parts accuracies and undependable machine results. Growth of these materials and deformation in cutting operations (such as milling and shaping) made the tooling problem a "headache." A satisfactory material solution was found in the use of sheet steels which were economical and did not show excessive fabrication and labor costs, especially in deep drawn die formings. Figs. 14 and 15 illustrate a type of instrument housing formerly made of sand-cast aluminum shapes requiring a series of machining operations. Figs. 16 and 17 show the duplicate functional design as converted to sheet steel manufacture. The case components are drawn and fabricated from sheet steel of approximate analysis as follows:

S.A.E. No. 1010 Cold Rolled No. 5 Temper

Carbon	0.05 to 0.15
Manganese	0.30 to 0.60
Phosphorus	0.045 Max
Sulphur	0.055 Max

The larger instrument housings are fabricated of welded structure compounded with stampings and deep drawings. Use of deep drawing dies and perforating equipment did away with expensive machining operations. Among many secondary advantages of steel is magnetic shielding of the instrument mechanism, which of course the aluminum forms could not provide.

The use of sheet steels, however, brought to light corrosion problems which were not present with cast aluminum alloys. Problems of oxidation, electrolysis, atmospheric corrosion, temperature changes, etc., required durable final finish coats to prevent resultant stripping and chemical attack of the underlying metals. Instrument cases for industrial applications may be used in atmospheres of widely different chemical properties, as in chemical plants; or may be subjected to abrasion and large temperature changes, as in heat-treating plants. A solution to this problem was found in subjecting the final fabricated sheet metal parts to a complete Bonderizing of the material, coating with a primer of Roxylin, and finally finishing with two coats of Roxylin finishing enamel. Salt spray tests and weathering tests under temperature and humidity extremes have shown these finishes to be comparable in life to the replaced finished cast materials. In many cases they present a more eye-pleasing appearance.

Little redesign of the interior functional mechanism was entailed. Case designs are based as much as possible upon deep-drawing processes, with door covers of compounded drawing and welded construction. Hinge parts of the door structure are spot-welded and riveted, while lock parts and other hardware are attached with anchor screws or, in some cases, by riveting or spot welding. Door warpage, typical of sheet metal housing design, is overcome by using cross-brace members of fabricated welded frame design within the door body. Gasket mountings for sealing instrument covers are obtained through the use of further sheet metal fabrication and welding.

Hardware items, conventionally fabricated of brass, with chrome or nickel plating, have been replaced to a great extent by lock parts of stamped steel. These steels are finished for corrosion resistance by an underlying copper plate, brass plate above, and a final finishing lacquer coat. The use of black oxide chemical finishing for ferrous parts, recently appearing in this field, results in a black non-reflective wear- and corrosion-resistant surface which provides an excellent base for clear lacquer finishes on various metal parts, at the same time furnishing an attractive coating.

In concluding this necessarily sketchy account of an infinitesimal portion of the apparatus industry's war-time problems, it may be said that American Technology has been equal to its task of carrying on our vital manufactures in spite of material and manpower shortages; and that the enrichment of our fund of knowledge will stand us in good stead in the future.

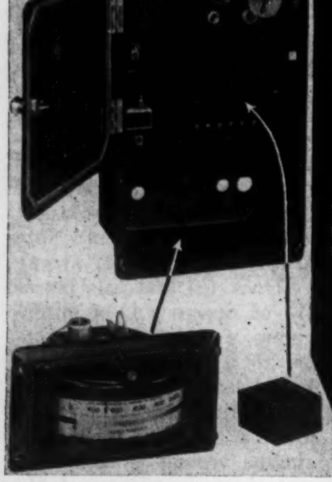


Fig. 14

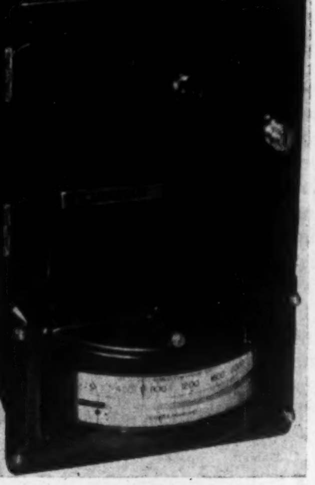


Fig. 15

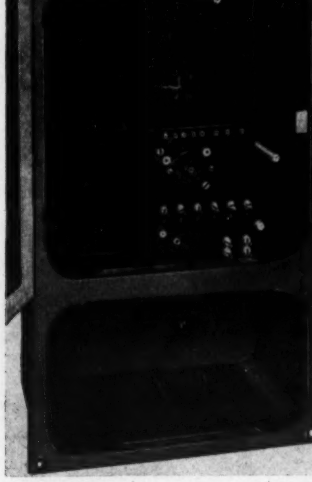


Fig. 16

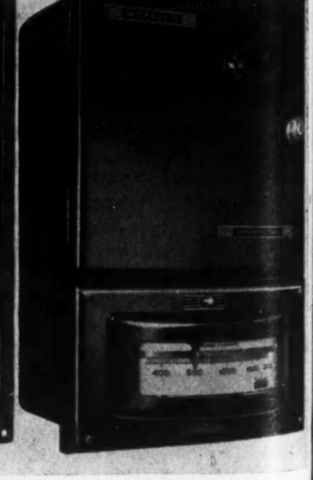


Fig. 17

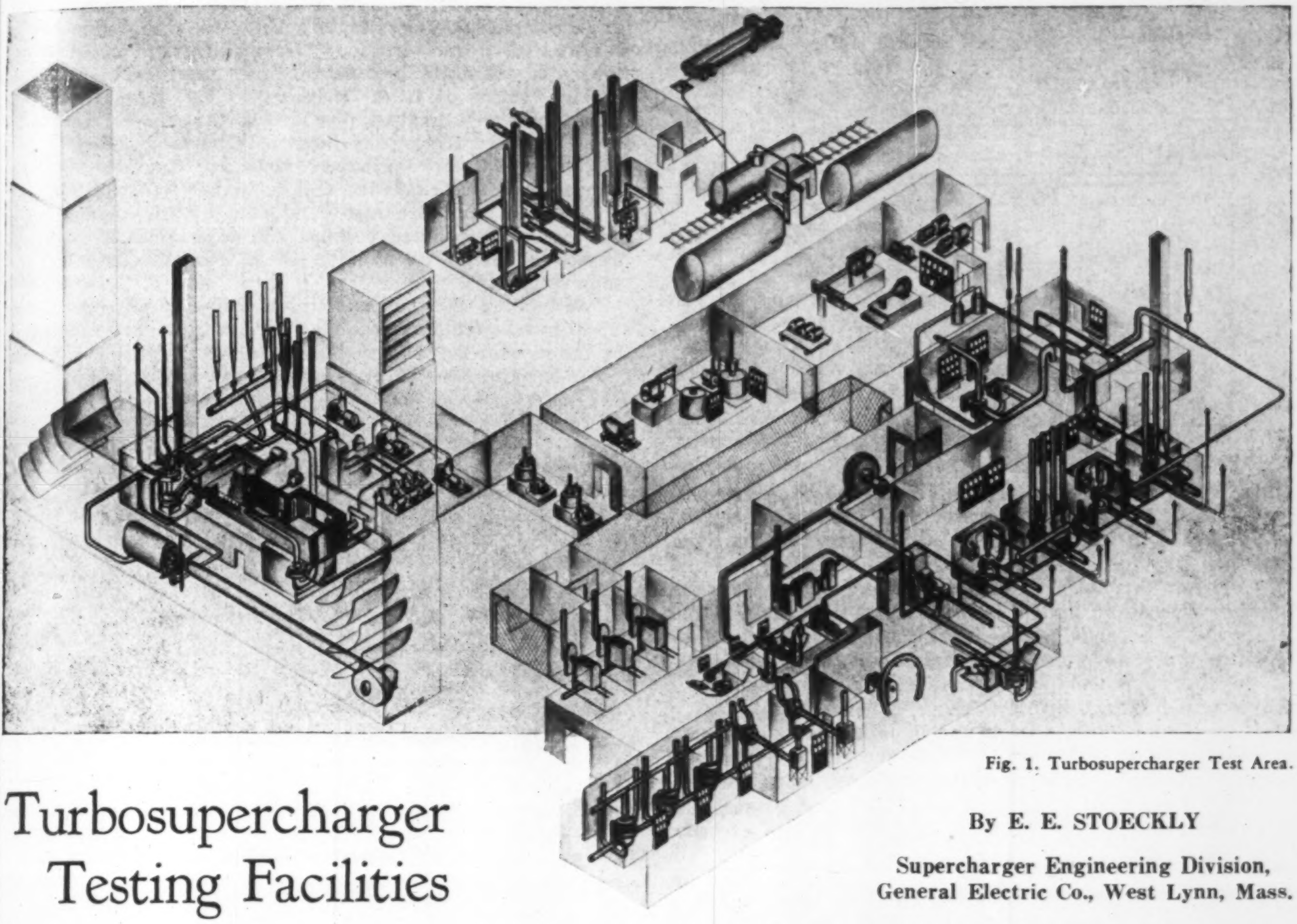


Fig. 1. Turbosupercharger Test Area.

Turbosupercharger Testing Facilities

By E. E. STOECKLY

Supercharger Engineering Division,
General Electric Co., West Lynn, Mass.

SUBSTANCE of paper presented at Annual Meeting of A.S.M.E. under auspices of Aviation Division

IN the thin air at today's fighting altitudes of 25 to 35,000 feet, unsupercharged aircraft engines develop less than 25% of their sea-level power. This loss in power is restored by supercharging by means of centrifugal-type air compressors which force a normal weight flow of air into the engine. When the power to drive the compressor is taken from the engine crankshaft, "geared supercharging" is employed; when the compressor is driven by an exhaust-gas turbine, "turbosupercharging" is employed. In high-altitude bombers and top-flight fighters, the two are combined.

At 35,000 feet, the power required by the gear-driven supercharger to compress the carburetor air to sea-level pressure is approx. 30% of that delivered by the crankshaft. On the other hand, the turbosupercharger supplies this sea-level pressure by utilizing otherwise-wasted exhaust-gas energy.

Compactly-designed exhaust-gas turbosuperchargers, which multiply engine power several times at high altitude, operate at terrific speeds with all parts stressed close to their ultimate limits. They must be not only carefully designed and built but tested with extreme care under all conditions of actual flight. To achieve this, the General Electric Co. has developed and set up test facilities in its Lynn (Mass.) River Works Plant, which enable the design engineers to determine performance and endurance limits of the many components, the turbosupercharger itself and even the complete turbosupercharged aircraft power plant.

Operation of this vast amount of test equipment (Fig. 1) requires at times as much as 400,000 lbs. of steam per hour, 4000 kwh of electric energy, 600 gph of fuel oil, and 400 gph of high-octane gasoline—enough for all the heating and power requirements of a good-sized city.

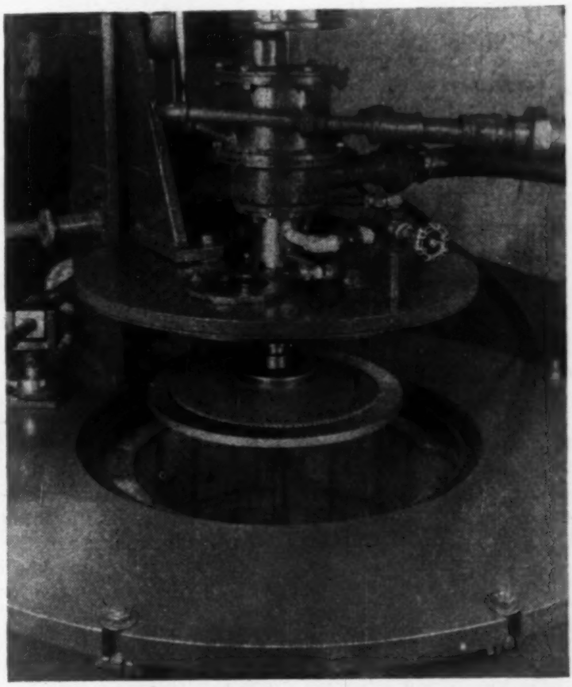


Fig. 2. Vacuum High-speed Test Stand.

VACUUM HIGH-SPEED TESTS

Special vacuum high-speed stands have been developed for destruction testing of impellers and wheels. (This same type of stand is used in production for stretching compressor impellers before they are bushed.) Fig. 2 is a view of one of these stands, consisting of a small air- or steam-driven high-speed turbine for rotating the wheel or impeller which is supported on a small flexible shaft inside an evacuated chamber. Drive turbines have been developed to rotate weights of 500 lbs. up to 30,000 rpm, 50 lbs. up to 55,000 rpm, and 10 lbs. up to 100,000 rpm. The wheel, impeller, or other object being high-speeded rotates about its own center of gravity. It is connected to the turbine through a small flexible

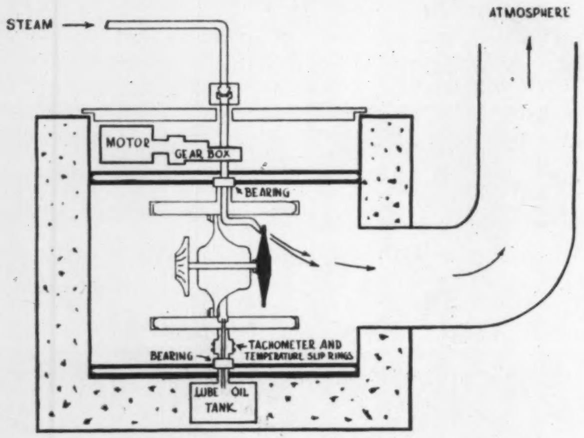


Fig. 3. Gyro Test Mechanism.

shaft, which is prevented from whipping by damping disks built into the lower part of the turbine. The chamber can be evacuated to 0.0001″ Hg. This decreases the rotational loss to a negligible value, minimizing the power required. The driving turbine is designed to bring standard supercharger wheels and impellers from standstill to 30,000 rpm in approx. 60 seconds. After testing, the rotating parts are brought to a stop by means of an air jet acting as a brake on the turbine wheel. Speed measurements are made by a magnetic pickup actuating a frequency meter calibrated in rps. Large numbers of wheels and impellers have been spun to destruction in order to determine the relative merits of various materials, different wheel contours, bolt hole sizes and locations, fillet sizes and shaft locating bosses. The stored rotating energy of some test wheels has exceeded 7,000,000 ft.-lbs.

As a standard production procedure, all wheels and impellers are high-speeded to 125% of their rated speed in vacuum high-speed stands. Total time required to load the stand, evacuate the chamber, bring the wheel or impeller to speed, maintain speed for two minutes, decrease speed to zero, break vacuum in chamber, and remove the tested object, is six to eight minutes.

GYROSCOPIC TESTS

During combat maneuvers, the motion of the plane combined with the high rotational speed of the turbosupercharger produces large gyroscopic forces. To determine the ability of the rotor parts to withstand these forces, a special gyroscopic test stand (Fig. 3) is used. The complete turbosupercharger rotating assembly is brought to full operating speed and is then rotated about an axis at right angles to the shaft, at a rate approximately equal to the maximum encountered in flight. The effect cumulatively encountered in the life of the unit in an airplane can be obtained on the test stand in a few moments.

COMPRESSOR PERFORMANCE

Five stands are available for the measurement of compressor efficiency by the temperature rise method. (See Fig. 4.) In this method, the power input is calculated from measurements of compressor air flow and compressor inlet and discharge temperatures. This method requires that no heat be lost between the inlet temperature measurements and the discharge temperature measurements. Thus careful lagging of the compressor casing and inlet and discharge lines is necessary. The theoretical power requirements for the pressure rise is calculated from measurements of compressor inlet temperature and compressor inlet and discharge pressure. Because of this method of power measurement, any type of power supply may be used. Owing to the critical effect of entrance and discharge conditions on compressor pressure measurements and compressor performance, care is taken to secure ideal flow conditions at both the inlet and the discharge. The arrangement is such that machines can be tested with radial, tangential, or double tangential compressor discharges. In the case of double tangential discharge machines, the two discharges are made symmetrical up to the point at which they feed into a common flow nozzle. The air to the compressor inlets is either at normal outdoor temperature or heated sufficiently to maintain a constant inlet temperature over a complete series of runs. Discharge blast gates and cone-shaped inlet throttles are provided so that the correct pressures, pressure ratios, and flows may be maintained.

Other compressor efficiency tests are conducted in the evacuated and refrigerated test cells that will be discussed later. Such tests are also conducted by the temperature rise method and make possible the determination of compressor efficiency at a given speed for various inlet air temperatures.

Two turbine efficiency test stands, using closely controlled superheated steam as the driving medium, are employed for the measurement of turbine efficiency. On one stand, the power output of the turbine is measured directly on a water brake, while on the other the temperature drop method is used in conjunction with a compressor for loading the turbine. The steam supply taken from a 200 lbs./in.^{2} header, is passed through electric steam superheaters which maintain a constant inlet temperature, and then through "critical drop" steam flow nozzles before entering the turbines. The discharge steam passes through a pressure and temperature measuring section before going to a water spray condenser. Tests are conducted to determine the performance of the turbine through its full operating range and to determine the variations resulting from slight changes of nozzle and bucket angles, clearances, and overlaps.

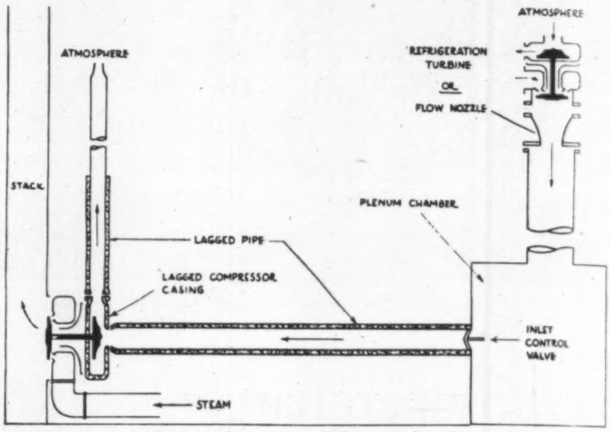
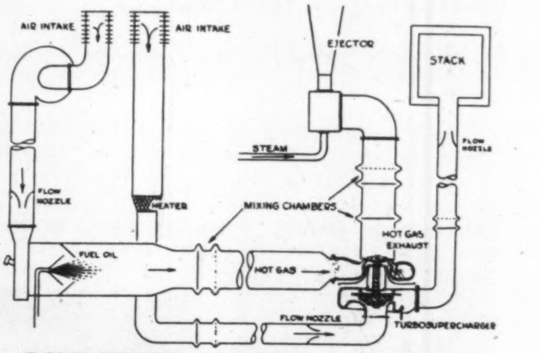


Fig. 4. Compressor Efficiency Stand.



TURBINE EFFICIENCY MEASURED BY COMPRESSOR HEAT BALANCE OR TURBINE TEMPERATURE DROP

Fig. 5. Hot Gas Turbine Efficiency Stand.

A stand for determining turbine efficiencies with high-temperature gas as motive power is also used. (Fig. 5) This testing takes account of possible variations in overlaps, clearances, and distortions resulting from hot gas operation. A certain number of correlation tests using hot gas are run to verify the performances obtained from steam tests.

In these tests fuel oil is used to produce hot gas. Both this fuel oil and the compressed air used for combustion, are carefully metered by means of flow nozzles before going to a special combustion chamber. After burning and before entering the turbine under test, the products of combustion pass through a mixing chamber which produces a uniform-temperature gas in which all stratification has been eliminated. Between the mixing chamber and the turbosupercharger nozzlebox, the exact gas temperature and pressure are measured by means of six quadruple-shielded thermocouples and three static pressure taps. The six temperature measurements are in two groups of three, approx. 10 ft. apart, with the second set located several feet ahead of the turbine nozzlebox. By using three thermocouples installed at one-third pipe depth and 120° apart at each point, the tendency toward stratification can be determined and an average temperature obtained. By placing the two sets of thermocouples 10 ft. apart, the rate of temperature drop along the pipe can be measured. To reduce stratification and to maintain the temperature as nearly constant as possible, the hot gas line from the combustion chamber to the turbine is lagged with 7″ of high-temperature insulation. The turbine wheel discharges its gases between two concentric rings in the sides of which are eight static pressure taps, four on the inside ring, and four on the outside ring. This is followed by a mixing chamber, before and after which temperature measurements are taken to make certain that an average exhaust gas temperature has been obtained. The turbine exhausts into a header containing a number of steam ejectors. Sufficient hot gas and exhausting capacity is available to test machines up to a pressure ratio of 10:1 between inlet and exhaust pressures.

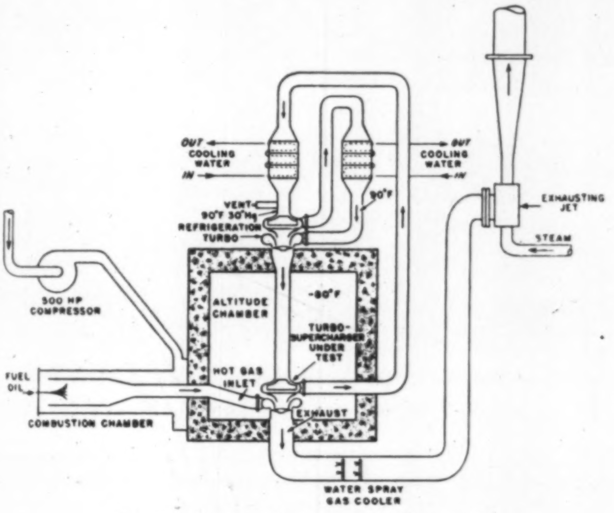

OUT
COOLING WATER
IN
OUT
COOLING WATER
IN
VENT
90°F 30″Hg
REFRIGERATION TURBO
90°F
EXHAUSTING JET
STEAM
300 HP COMPRESSOR
ALTITUDE CHAMBER
-80°F
TURBO-SUPERCHARGER UNDER TEST
FUEL OIL
HOT GAS INLET
EXHAUST
COMBUSTION CHAMBER
WATER SPRAY GAS COOLER

Fig. 6. Closed-refrigeration-cycle Test Cell.

For these tests, the turbine can be loaded either by means of its own compressor or by means of a water brake. If the compressor is used as a load, careful measurements are made of the air flow and the compressor inlet and discharge temperatures. To hold constant inlet air temperatures, regardless of changes in outside ambient temperatures, air is first drawn through a steam heater. Mixing chambers are used both in the inlet and the discharge lines to obtain good average temperature. Two sets of three thermocouples each are used in both lines to determine the change of air temperature along the length of the lagged inlet and discharge air lines. Provisions have been made for flow nozzles in both the inlet and discharge lines so as to be able to make a double check on compressor air flow.

HIGH-ALTITUDE TEST CELLS

Completed turbosuperchargers are tested in cells in which high altitude conditions can be maintained. When the primary purpose of the test is to secure information on the turbine, altitude temperature and pressure conditions are closely controlled. Hot gas from a special combustion chamber is available at temperatures up to 1800°F., at pressures up to 70″ Hg and at flows up to 450 lbs. per min. Altitude turbine cooling air is duplicated with respect to both pressure and air flow.

For tests involving the endurance or performance of the compressor, air that is cooled to the low temperatures encountered at high altitudes is used. To take care of the great number of development tests, seven altitude test cells are available. In three of these the compressor inlet air is throttled from normal outdoor sea level conditions. One cell is equipped with a closed-cycle refrigeration system (Fig. 6) in which the compressor discharge air is directed through cooling coils, expanded through a refrigeration turbine, and delivered back to the compressor inlet under altitude pressure and at temperature down to −80°F. The maximum capacity of this refrigeration cycle is approximately 450 lbs. of air per minute. In the remaining three test cells outside air is refrigerated to approx. −100°F. by means of a compression, dehydration and expansion cycle.

Six of the cells are equipped with special reverse-flow combustion chambers for supplying hot gas to simulate the exhaust gas from aircraft engines. For special tests several of the chambers have been operated for considerable periods with a discharge gas temperature of 2000°F. without showing undue signs of deterioration. One stand receives hot exhaust gas directly from an actual aircraft engine and is described later.

To obtain altitude conditions, all of the stands are exhausted by means of steam ejectors. Compared to centrifugal or positive-displacement exhausting equipment, the higher operating cost of steam ejectors is offset by lower initial and maintenance cost. Instead of being limited to a definite altitude as are centrifugal exhausters, steam ejectors operate over a very wide range, simply giving lower weight flows as the altitude increases. The following table gives this variation based on 100% capacity at 40,000-ft. altitude:

Altitude, ft.	10,000	20,000	30,000	40,000	50,000
Capacity	310%	250%	175%	100%	37%

A number of the test cells have their exhausts directly interconnected so as to make the greatest use of a fixed number of jets. The rated exhausting capacities of the various test cells when operating at 40,000 feet range from 300 to 1200 lbs. per minute.

One of the test cells is equipped with an air-to-gas heat exchanger to cool the exhaust gases from the turbosupercharger before entering the exhaust ejectors. In the remaining six cells the exhaust gases are cooled by means of direct evaporation from exhaust gas cooling sprays.

The refrigeration cycle shown on the right side of Fig. 7 consists of compressing normal sea-level air by means of single-stage geared compressors to approximately 22 lbs./in.^{2} gage. The air is then cooled by means of finned air-to-water cooling coils to approximately 90°F. Coils con-

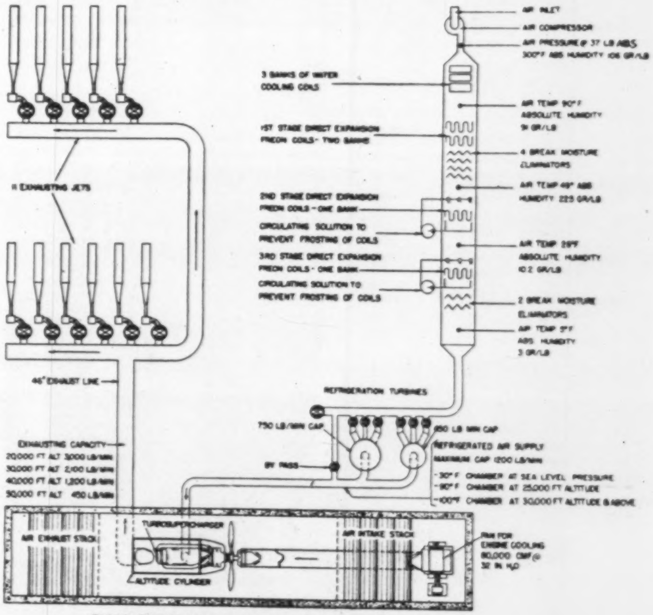

AIR INLET
AIR COMPRESSOR
AIR PRESSURE @ 37 LB ABS
300°F ABS HUMIDITY 106 GR/LB
3 BANKS OF WATER COOLING COILS
AIR TEMP 90°F
ABSOLUTE HUMIDITY
91 GR/LB
1ST STAGE DIRECT EXPANSION FREON COILS - TWO BANKS
4 BREAK MOISTURE ELIMINATORS
11 EXHAUSTING JETS
AIR TEMP 49° ABS
HUMIDITY 22.3 GR/LB
2ND STAGE DIRECT EXPANSION FREON COILS - ONE BANK
CIRCULATING SOLUTION TO PREVENT FROSTING OF COILS
AIR TEMP 29°F
ABSOLUTE HUMIDITY
10.2 GR/LB
3RD STAGE DIRECT EXPANSION FREON COILS - ONE BANK
CIRCULATING SOLUTION TO PREVENT FROSTING OF COILS
2 BREAK MOISTURE ELIMINATORS
AIR TEMP 5°F
ABS. HUMIDITY
3 GR/LB
46″ EXHAUST LINE
REFRIGERATION TURBINES
750 LB/MIN CAP
450 LB MIN CAP
EXHAUSTING CAPACITY
20,000 FT ALT 3000 LB/MIN
30,000 FT ALT 2,100 LB/MIN
40,000 FT ALT 1,200 LB/MIN
50,000 FT ALT 450 LB/MIN
BY PASS
REFRIGERATED AIR SUPPLY
MAXIMUM CAP 1200 LB/MIN
-30°F CHAMBER AT SEA LEVEL PRESSURE
-90°F CHAMBER AT 25,000 FT ALTITUDE
-100°F CHAMBER AT 30,000 FT ALTITUDE & ABOVE
TURBOSUPERCHARGER
AIR EXHAUST STACK
AIR INTAKE STACK
FAN FOR ENGINE COOLING 80,000 CMF @ 32 IN H2O
ALTITUDE CYLINDER
ENGINE TEST STAND WITH ALTITUDE CYLINDER

Fig. 7. Engine Test Stand Equipment Schematic Diagram.

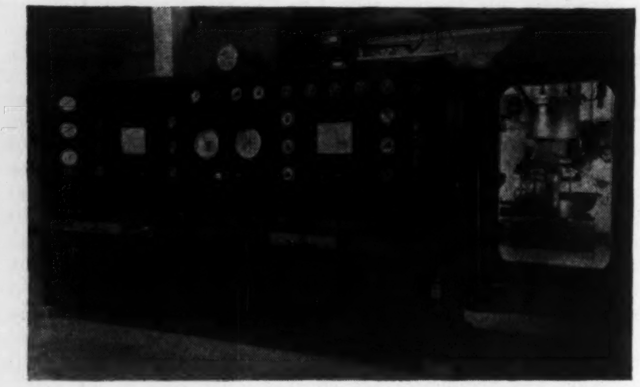


Fig. 8. Hot Gas Altitude Test Stand.

taining Freon further reduce the temperature to approximately 49°F. In summertime when humidity is high, a large proportion of the moisture in the incoming air is condensed in this cooling process, and is separated from the air by means of moisture eliminators. A second bank of Freon coils reduces the air temperature to approx. 26°F. At this temperature, frosting on the coils would interfere with continuous operation; therefore the entire coil surface is flooded with a non-frosting solution. Thus, the moisture that would normally remain on the coil surface in the form of frost is absorbed into the continuously-recirculated frost-preventive solution. To maintain a constant solution strength a small quantity is automatically withdrawn, passed through an evaporative concentrator and reintroduced into the cycle. A third bank of Freon coils reduces the temperature to approximately 5°F. with a similar scheme for the prevention of frosting of the coils. The third bank of coils is followed by a moisture eliminator to decrease the carry-over to as low a value as possible.

The air at 5°F. and approx. 20 lbs./in.^{2} gage pressure is expanded through a specially constructed refrigeration turbine to the altitude pressure maintained in the test cell. The energy removed from the air by the refrigeration turbine is absorbed by a standard supercharger compressor. In three of the test cells no attempt is made to utilize this energy because of the wide range over which the compressor must operate to absorb the varying power output of the turbine. In the test cell which has a closed cycle, the refrigeration turbine is loaded by a compressor which boosts the pressure of the air supplied.

To allow for a wide range of operation, in some cells the refrigeration turbines are equipped with several nozzle arcs of different areas, while others are equipped with controllable nozzle areas. In these refrigeration cycles, the minimum air temperature available at sea-level chamber pressure is approx. −30°F. As the chamber pressure is decreased, the energy available to drive the refrigeration turbine increases and results in a lower air discharge temperature. These temperatures reach −90°F. at test cell altitudes of 25,000 feet, and −100°F. or colder at altitudes above 30,000 feet. With this equipment, a temperature of −90°F. at the compressor unit under test has been reached within 20 minutes of a warm start of all the refrigeration equipment involved.

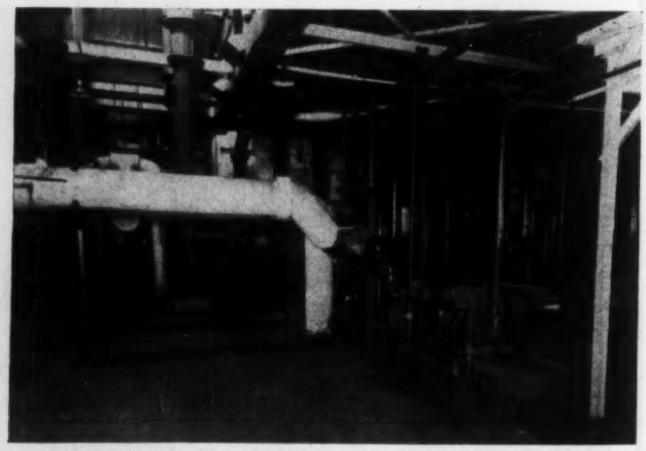


Fig. 9. Refrigerating and Exhausting Equipment for Altitude Test Stands. Fig. 10 (Hot Gas, Altitude, and Refrigeration Control Board) is the front-cover photograph.

Among many tests on completed turbosuperchargers made in these cells are accelerated life tests on new bucket and wheel material, tests for nozzlebox distortion, compressor endurance, lubrication under low temperatures and pressures, oil leakage, compressor performance, turbine performance, and the 150-hour type test for the Army Air Forces.

Experience has demonstrated that in order to get accurate test results on higher-speed higher-altitude turbosuperchargers, it is necessary to test them under closely controlled altitude pressure and temperature conditions. Fig. 8 shows a typical altitude test cell in which all altitude conditions are duplicated except for the temperature of the air going to the compressor inlet. This type of plant is used mainly for accelerated life tests on all parts of the turbine and tests for mechanical endurance of bearings, lubrication systems and compressors. Automatic controls maintain constant chamber altitude, hot gas temperatures, and lubricating oil temperatures. All important temperatures and pressures throughout the turbosupercharger on test are recorded.

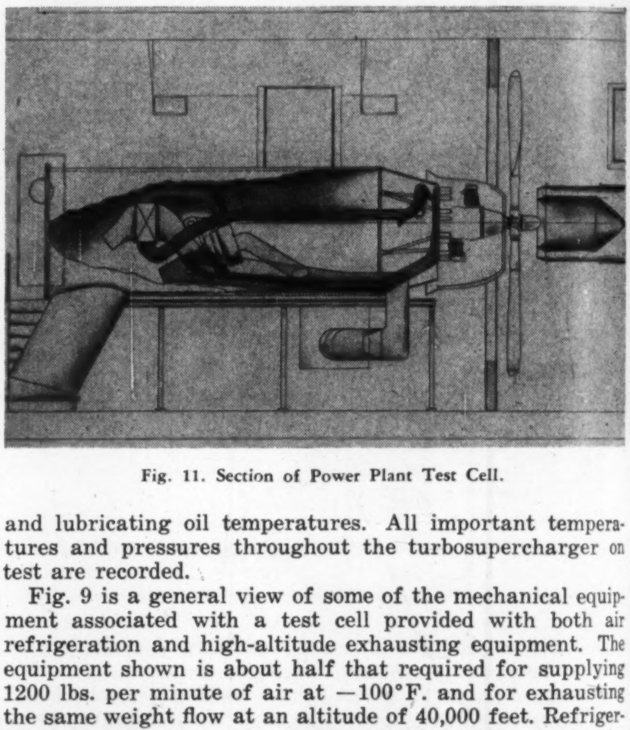


Fig. 11. Section of Power Plant Test Cell.

Fig. 9 is a general view of some of the mechanical equipment associated with a test cell provided with both air refrigeration and high-altitude exhausting equipment. The equipment shown is about half that required for supplying 1200 lbs. per minute of air at −100°F. and for exhausting the same weight flow at an altitude of 40,000 feet. Refrigeration equipment is on the right-hand side; exhausting equipment on the left. The control board necessary for complete remote control operation of a 1200 lb. per minute plant is shown in Fig. 10 [front-cover photo.—Ed.]. In the center can be seen the automatic controllers for maintaining constant altitude air temperatures. Recorders in addition to the ones shown are provided for all of the important temperatures and pressures of the unit on test.

COMPLETE POWER PLANT TEST CELL

A special engine test cell has been constructed to study the operation of any particular type of turbosupercharger as an integral part of a given power plant unit. Fig. 11 shows a typical test installation in an altitude cylinder.

The engine of the power plant under test is mounted on the forward wall of the altitude cylinder. Normal equipment such as turbosuperchargers, air intercoolers, engine oil coolers, regulators, integral flight controls, oil cooler flap controls, and carburetor air temperature controls are mounted back of the forward wall of the altitude cylinder in exactly their same relative location to one another and to the engine as in the actual plane installation. Refrigerated air is introduced through the forward wall for combustion and cooling of the power plant in exactly the same manner as it would be introduced by the airplane air scoop. This air can be maintained at any temperature down to —100°F. The pressure at which it is delivered can be controlled to equal the sum of the altitude static pressure and the air scoop ram pressure for a particular airspeed of the plane. The exhaust gases are removed from the rear of the altitude cylinder through a 46″ pipe line. Water is injected into the turbosupercharger exhaust soon after it leaves the turbosupercharger discharge in order to decrease the temperature of exhaust gases handled. The flow diagram of the refrigeration and exhausting system was shown in Fig. 7.

In order to record the many simultaneous pressure readings required, 256 manometers, each 60″ long, in which various density fluids can be used, have been installed in a special room. The grouping and lighting have been so arranged that all pressure readings plus pertinent information such as engine speed, oil pressure, flap and intercooler door positions are recorded on photographic film by two cameras. Temperatures are recorded automatically on a three-range 140-point flight test recorder. Provisions are also made for recording up to 60 temperatures on precision potentiometers and 60 additional temperatures on semi-precision potentiometers.

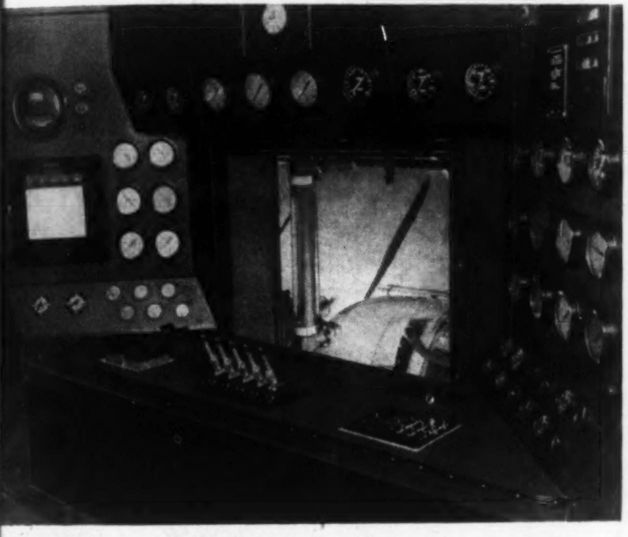


Fig. 12. Control Board for Airplane Power Plant Test Stand.

The control board is shown in Fig. 12. Here are mounted all the test instruments for the particular test being conducted in addition to the controls and instruments normally supplied for a single engine. Three grades of gasoline are available, the flow of which is measured by double-range flow meters. Remotely-controlled air-operated valves make it possible to change from one grade to another during a test. Exhaust gas and other important temperatures are recorded on several multipoint recorders.

A separate oil cooling and filtering installation has been provided for tests which do not call for data on the actual airplane engine oil cooler under altitude conditions. In this system automatic controls maintain constant oil temperatures to the engine.

CONCLUSION

The testing facilities of the General Electric Turbosupercharger Division provide the data required to help perfect not only the turbosupercharger unit, but the operation of the unit with the remainder of the power plant. There is no limit to testing such as described here. Component parts are not delicate and do not require flight testing and checks. "Take-off time" can be set in advance, as clouds, storms, sleet or snow are all outside the substratosphere chamber and control room cabin. The human element has no part to play, in that test operators are always at sea level even though the equipment on the other side of the wall is 50,000 feet up and —100°F. below zero. Pushing a few buttons and setting a few controls makes the weather and conditions perfect for the test under consideration.

MERIAM
A STANDARD OF PERFORMANCE

★ During the past 32 years we have solved numerous measurement problems by supplying standard or special instruments to accurately measure pressures, vacuums and flows of liquids and gases. We have constantly improved, developed and diversified the line so as to meet fully all needs of the field.

U-TYPE MANOMETERS

The Clean-Out Manometer for line pressures up to 100 lbs. per sq. in. A wing nut permits the Manometer body and tube to be disconnected from the head—the tube cleaned with a brush furnished or tube replaced, and the instrument reassembled without disconnecting the head section from the piping. Send for Bulletin No. 1.

The Model A-204 Manometer for line pressures up to 400 lbs. per sq. in. These instruments are built with heavy walled annealed straight Pyrex tubes, gland packed top and bottom in steel end blocks and clamped to the body at fixed intervals to prevent distortion. Bulletin No. 10 gives complete details.

WELL-TYPE MANOMETERS

Direct reading Manometers for line pressures up to 250 lbs. per sq. in.—of standard construction, available in both wall and flush front panel mounting designs in ranges from 6″ to 100″. Ask for Bulletin B.

SIGHT FEED BUBBLER

This Sight Feed Bubbler with bowl of Pyrex glass is good for line pressures up to 50 lbs. per sq. in.; of plastic, for pressures up to 100 lbs. Sturdily built in brass or semi-steel construction. Needle valve controls bubbler rate. Ask for Bulletin 21.

THE MERIAM CO.
1945 West 112th St., • Cleveland, Ohio

MERIAM
SINCE 1911
★
MANOMETERS, METERS AND GAUGES FOR THE ACCURATE MEASUREMENT OF PRESSURES, VACUUMS AND FLOWS OF LIQUIDS AND GASES

The "Temp-Turb" Temperature Control System

By J. R. CAMPBELL, General Electric Co., Ontario, Calif.

THE amount of work available from any basic temperature-sensitive element is relatively small and must be substantially amplified by some form of external energy before response to temperature change can be made to command the control means. In aircraft the control means might be an exit flap, such as on an intercooler; a butterfly valve, such as in a heating and ventilating duct; a mixing valve, such as in a heating and ventilating system; shutters or flaps for oil coolers; dump valve for thermal de-icing system; etc.

The Temp-turb system of temperature control uses the kinetic energy of the flowing fluid being controlled to amplify the work done by the basic temperature-sensitive element. The kinetic energy available in fluid flow systems in aircraft is generally substantial and enough energy can be harnessed to operate control means without introducing a harmful pressure drop.

Fig. 1 shows a Temp-turb Control Unit, as used in the Douglas A-20 for controlling the temperature of air leaving a combustion heater. This air is for cabin heating, windshield defrosting and turret heating. The Temp-turbs are set to maintain a control point of 200°F. ±15°F. and actually control to within ±5°F. As shown in Fig. 2, the Control Unit is furnished as an integral part of the modulating valve. Operation of the assembly is to allow more air to flow over the heater as temperature tends to increase, and to reduce the air flow as temperature tends to decrease. Heaters in this system are ram-operated.

Fig. 3 indicates the operation of the rotor or turbine wheel for the type of Temp-turb as used on the A-20. Turbine blades are made of 0.005" thick high-activity bimetal and are calibrated to be straight at the control point. Any deviation from the control point temperature results in a curvature of the turbine blade (the direction of curvature depending upon the direction of the temperature deviation). As the device is a radial flow turbine, the curvature of the blade imparts a torque to the rotor which is transmitted through a gear reduction to the modulating valve.

After the turbine blades are formed and stabilized (to maintain calibration under all conditions to which control might be subjected) it is not feasible to vary the control point of the unit by varying the form of the blades. Therefore, the angle at which the fluid enters the rotor is varied. Referring to Fig. 1, the inlet guide vanes are mounted as cantilevers at the edge of the inlet nozzle and their free ends engage a shift ring by means of small pins. Moving the shift ring either direction from neutral varies the direction of fluid flow over the rotor to either side of pure radial flow. The amount of deviation from pure radial flow is determined by the amount the shift ring is moved.

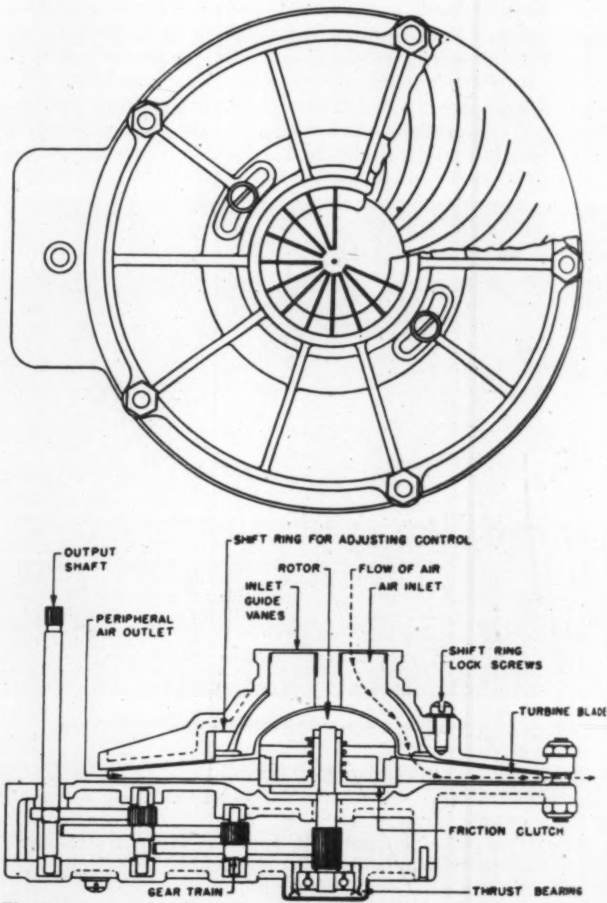
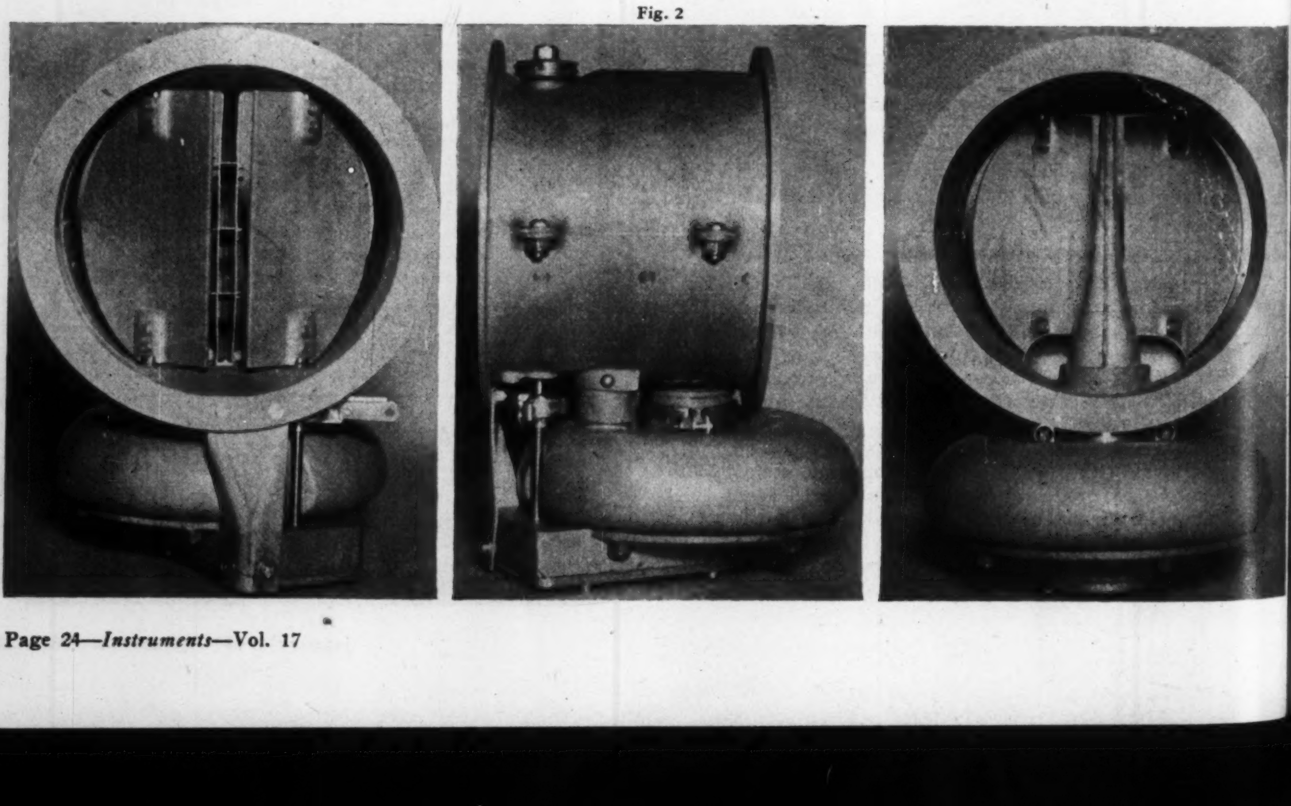


Fig. 1

Fig. 2



FULL TEXT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Aviation and Heat Transfer Divisions.

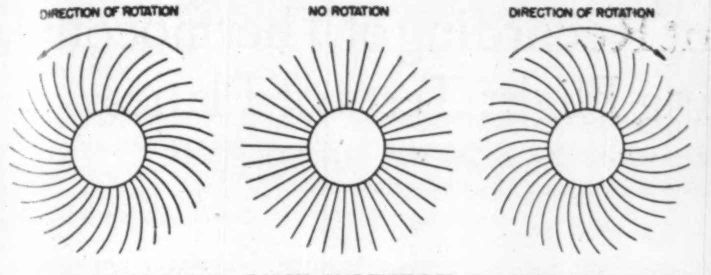

DIRECTION OF ROTATION
NO ROTATION
DIRECTION OF ROTATION
EXAGGERATED CURVATURE OF TURBINE BLADES WITH TEMPERATURE BELOW CONTROL POINT.
AT CONTROL POINT TEMPERATURE BLADES ARE STRAIGHT AS SHOWN
EXAGGERATED CURVATURE OF TURBIN BLADES WITH TEMPERATURE ABOVE CONTROL POINT

Fig. 3

When the flow through the rotor is deviated from radial, the rotor assumes a new temperature control point. This adjustment allows the control point to be varied about ±40°F. from the normal.

The assembly shown in Fig. 2 operates on a sample of air which varies from about 5% to 10% of rated flow for a full open valve. Fig. 4 (a partial cut-away of the assembly shown in Fig. 2) shows the inlet scoop and the exhaust outlet from the turbine back to the duct.

Numerous other applications of the Temp-turb principle of temperature control are in the development stage; however, the example mentioned above should provide an adequate picture for understanding of the system in general.

The work available in a Temp-Turb unit is a function of:

1. Deviation from control point.
2. Mass flow of fluid, which for air has to be corrected for

a. Temperature } density
b. Altitude }

The temperature sensitivity is a function of:

1. Massiveness of basic temperature-sensitive elements.
2. Velocity of fluid being controlled.
3. Gear ratio between rotor and control valving.
4. Thermal lag of the system.

When designing a Temp-turb Unit for a specific application, it is first necessary to determine the following:

1. Control point.
2. Degree of accuracy to which temperature must be controlled.
3. Maximum work required to operate valving or control means. This may be broken down into:
   a. Maximum torque required.
   b. Rate at which control means must be moved when operating under maximum torque conditions.
4. Mass flow rate of the fluid in system.
5. Allowable pressure drop (drop due to Temp-turb).
6. If system involves flow modulation, the minimum flow allowable. In this system, it always is necessary to have a sample of the fluid flowing over Temp-turb rotor at all times. It is not practical to design for a minimum flow of less than the amount needed for a sample.
7. Allowable space.
8. Allowable weight.
9. Cross section area of ducting or piping in the zone where Temp-turb is to be installed.
10. Whether or not the control point has to be adjustable:
   a. as a service operation.
   b. as an "in use" operation.

General characteristics of the Temp-turb system of temperature control are:

1. Inherently non-hunting. The deflection of the blades, whether made of temperature-sensitive material or actuated by a temperature-sensitive element, is proportional to temperature changes. Therefore, the output of the rotor is proportional to temperature changes. A large temperature deviation produces a large corrective force and a large rate of correction. A small deviation produces a small corrective force and a small rate of correction. As temperature error is being corrected, the correcting force and speed (produced by rotor) are reduced in proportion to the error until the control point is reached, at which time corrective force and speed of correction become zero.

Numerous tests under transient conditions have proven that the system is inherently stable. Of course, the thermal balance of the system must be within reasonable limits, and the gear ratio between rotor and control means also must be within reasonable limits.

2. Falling torque characteristics with velocity pressure increases above a certain value. The turbine blades, being operated by resilient thermoelements, are spring-loaded into proper position. This feature allows the blades to be blown into a neutral position under conditions where excessive velocity pressure might result in damaging loads or wear on the mechanism. This factor is of value on high-speed aircraft where ram pressures at times become quite high.

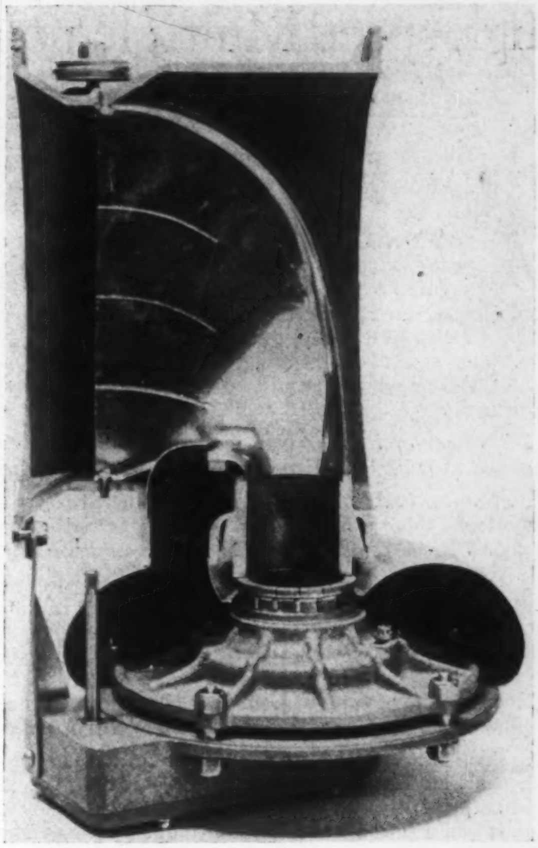


Fig. 4

3. Adequate sampling of fluid being controlled. Temperature-sensitive elements have large area exposed to flowing fluid, which is particularly helpful under conditions wherein there is "temperature layering" in the duct. Also, system is adaptable to special types of sampling scoops.

4. Low thermal lag. Bimetal temperature-sensitive elements are thin and subjected to relatively high velocity fluid flow, resulting in almost instantaneous response to temperature changes.

5. Not affected by vibration. The torque produced by a vibrating turbine blade is the same as for a non-vibrating blade.

6. Output related to demand on unit. As flow rates increase, causing greater loads on control means, the rotor output increases accordingly.

7. The type of Temp-turb assembly shown in Fig. 2 has the characteristic of not being affected by radiant heat from a glowing combustion chamber on a combustion heater. The sampling scoop and location of the Temp-turb control unit make the device respond to air temperature only. This condition is of importance when the control is mounted immediately downstream from the combustion heater.

Experience to date indicates no unusual difficulties from a manufacturing standpoint. Any remarks on cost must be predicated on the somewhat limited manufacturing and commercial experience encountered to date. Based on this experience, it may be said that Temp-turb type controls cost no more than competitive devices.

Concerning service life, Temp-turb controls on test have demonstrated that they have a trouble-free life of greater duration than other forms of controls used for the same operations. This probably is largely due to freedom from complexity. Two units on life test actually worked better after 3,000 hours than at the start of the test, due to "wearing in" of bearings.

Temperature range, over which the Temp-turb principle could be applied, is approximately from −60°F. to 600°F. This is on the basis of response and durability of the bimetal temperature-sensitive elements. Greater problems are offered in bearing design at extreme temperatures and at this time the bearings and their lubrication actually determine the applicable range. On this latter basis, the range is about −60°F. to 350°F.

Performance curves and mathematical relationships of various functions are omitted because they would be far too voluminous in order to be adequate.

High-speed Multiple-point Recording of Thermocouple Temperatures During Flight Tests of Planes

By I. MELVILLE STEIN, ALBERT J. WILLIAMS, Jr. and WM. RUSSELL CLARK
Research Department, Leeds & Northrup Co., Philadelphia, Pa.

MEASURING exhaust gas temperatures in flight testing large planes requires the use of thermocouples of special design, and requires also an instrument capable of recording, rapidly, accurately and directly, a large number of temperatures. This problem was studied by special subcommittees of the N.A.C.A. and of the A.S.M.E. and the requirements (abbreviated) were as follows:

1. Number of Points. One instrument to record temperatures of at least 50 thermocouples, preferably 100 or more.

2. Ranges and Accuracy. The temperatures involved range from those approaching −100°F. to those approaching 2,000°F. A limit of error of 5°F. was desired.

3. Recording Speed. It was desired to record as many temperatures as possible while the plane was rapidly gaining or losing altitude. If possible, 20 or more readings in ten seconds, and the record to appear immediately on a printed chart or tape. It was recognized that without resorting to photographic recording, it might be necessary to allow more than one-half second per point for recording.

4. Push-Button Operation. Switching arrangement to be such that, by means of push-button operation, the recorder could be promptly connected to any one of the many thermocouples and allowed to record continuously the temperature of that thermocouple.

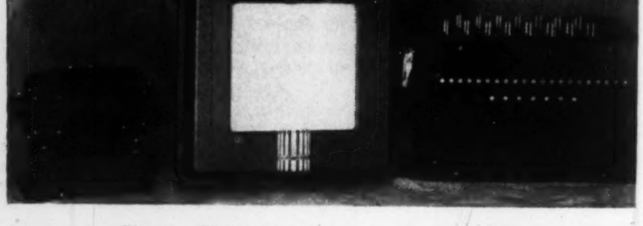


Fig. 1. Flight Test Recorder and accessories.

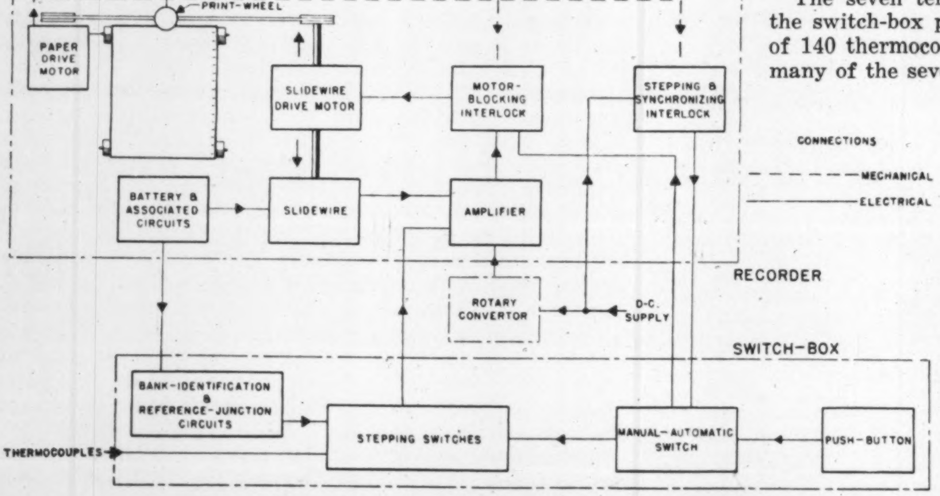


Fig. 2. Block diagram of Flight Test Recorder and accessories.

5. Flight Requirements. Instrument must operate from the plane's d-c. power supply; its accuracy and reliability must not be unduly influenced by changes in level, by vibration or by wide range of ambient temperatures. It should not produce radio interference and should be as small and light as practicable.

GENERAL DESCRIPTION

Fig. 1 shows the recorder and its accessories: a multiple-point switch box and a small rotary converter. Weights and dimensions: Recorder: 110 lbs.; 18⅜" × 20⅛" × 12⅞"; Switch Box: 55 lbs.; 17⅞" × 11$\frac{5}{16}$" × 9$\frac{11}{16}$"; Rotary Converter: 35 lbs.; 11½" × 9¼" × 6".

The recorder proper is designed to operate from a 115-volt 60-cycle supply. The switch box and one or two auxiliary circuits in the recorder are designed to operate directly from the plane's d-c. supply (usually 24 or 28.5 volts). The small rotary-converter is used to obtain the 115-volt 60 cycle supply for the recorder proper. Total power requirement from d-c. supply: 220 watts continuous, plus maximum momentary 95 watts when all stepping switches are reset simultaneously.

The recorder is provided with two ranges, one spanning 800°F. (−100 to +700°F.) and the other spanning 950°F. (1050 to 2000°F.), for copper-copnic and chromel-alumel thermocouples respectively. These particular ranges (with a 350° gap) and calibrations met the requirements of a particular problem. If, in some other problem, temperatures were to be measured in the range where this gap exists, the matter could be handled by slightly expanding the two ranges (at some sacrifice of precision) to close the gap, or by adding a third range closing the gap and overlapping the other two ranges.

The range changing is completely automatic.

Fig. 2 is a block diagram of the recorder circuit, that of a null potentiometer. The recorder contains no galvanometer, is not affected by changes in level or by acceleration, is built to withstand airplane vibrations as mounted in the usual anti-vibration frame. The thermocouple voltage is modulated by a vibrating element and then passes through an electronic amplifier. Amplifier output is sufficiently powerful to operate a reversible motor, which moves the balancing contact on the potentiometer slidewire. Associated with the potentiometer is a resistance-capacitance network which provides appropriate damping. The vacuum tubes in the amplifier are all of standard types; their life expectancy is at least 1000 hours.

The seven telephone-type keys at the center of the switch-box panel (Fig. 3) control the circuits of 140 thermocouples arranged in banks of 20. As many of the seven banks as desired may be cut out of service by throwing down the respective keys. These may be cut out of service in any order and, even if all but one of the banks are cut out of service, the recorder will continue to recycle on the 20 couples connected to the remaining bank. The bank on which the recorder is operating at any moment is indicated by a signal lamp above the bank key. The longer row of signal lamps above the bank signal lamps indicates the particular couple, in any bank, that is being recorded at the moment. This row contains 21 lamps although there are only 20 couples in each bank. The ad-

---

FULL TEXT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Aviation and Industrial Instruments and Regulators Divisions.

ditional point on each bank is used for "bank identification" on the recorder chart, as will be discussed under "Operating Characteristics."

Connections to thermocouples are made by means of the plug-connectors at the top of the switch-box. Each plug-connector handles 10 couples so that there are two plug-connectors for each of the seven banks. The "power" plug-connector at the extreme left handles the interconnections between the switch-box and the recorder proper.

A quick-acting push-button (below fifth and sixth bank keys) provides push-button control of the bank switches, as mentioned in outlining the requirements. The telephone key below the first and second bank keys is a selector switch to give control of the switching to the recorder mechanism or to the push-button.

The switch-box housing is copper-lined to eliminate radio interference. The relays, switches and other parts in the switch-box have been chosen to withstand plane service. The selector switches (Fig. 4) are of a type which has undergone exhaustive development for use in automatic telephone circuits; all sliding contact surfaces are heavily gold-plated.

OPERATING CHARACTERISTICS

Accuracy, Sensitivity and Speed. The sensitivity of the recorder and the readability of the chart are better than ±0.25% of the scale range and the limit of error is less than ±0.5% of the scale range. The time required for recording is 1.63 seconds per point so that all 147 points (140 thermocouples and 7 bank-identification points) are covered in four minutes. The recorder is so designed that 1.63 seconds permits a complete null balance on each point, whether successive points are at nearly the same temperature or are at the extreme ends of the 10" chart. The constant time-cycle makes it unnecessary to group the thermocouples according to their temperatures: they may be grouped according to the airplane's units.

A complete record of all 147 points is obtained without crowding on only an 8" length of chart. An 11" length of chart being always visible, at least one recording for each thermocouple is always visible. This is for a chart speed of 2" per minute. By throwing a lever, the chart speed may be reduced to 4" per hour (to record continuously the temperature of one thermocouple).

The normal balancing characteristic of the instrument, recorded automatically by adding a pen to the print-wheel carriage and using an increased chart speed, is shown in Fig. 5 (curve marked "damped"). The balancing characteristic with the damping removed is shown also in Fig. 5. These curves are for a chart traverse approx. 40% of full chart width and chart speed more than 20 times normal. From the damped curve, it can be inferred that for a full-scale traverse one-half of the 1.63-sec. time-cycle would be required for the linear portion of the traverse and three-tenths for the residual oscillations, giving a total of eight-tenths of the cycle. As may be seen from Fig. 6, more than 92% of the cycle is available for balancing. Analysis shows also that, without damping, the oscillations would be sustained beyond the end of the cycle and would cause erratic operation.

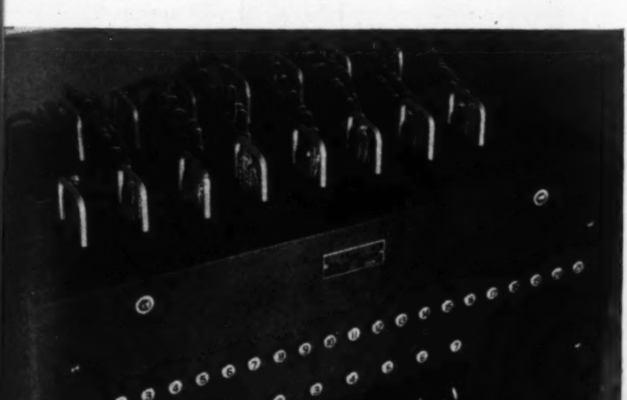


Fig. 3. Switch-box, showing panel details.

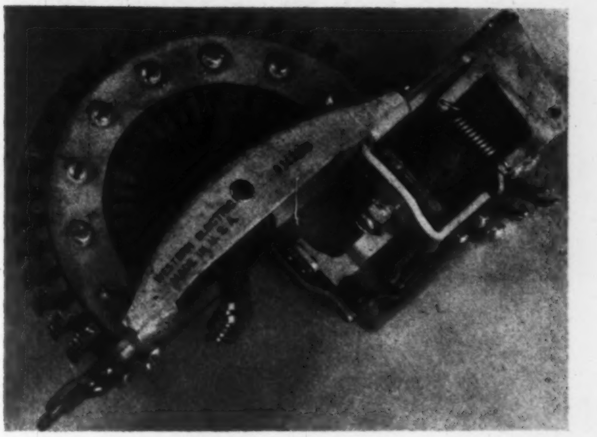


Fig. 4. Selector switch.

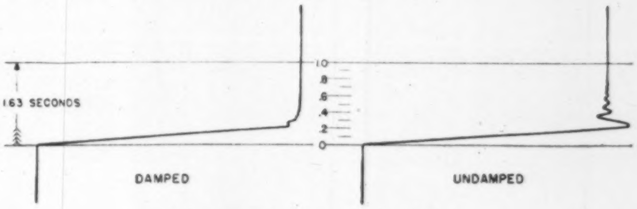


Fig. 5. Balancing characteristic.

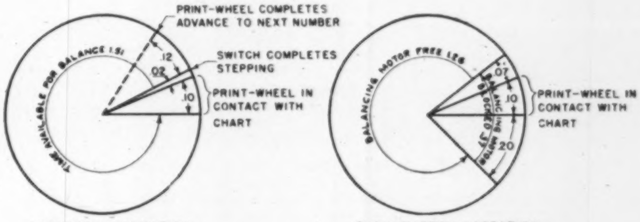

PRINT-WHEEL COMPLETES ADVANCE TO NEXT NUMBER
SWITCH COMPLETES STEPPING
TIME AVAILABLE FOR BALANCE 1.51
.12
.02
.10
PRINT-WHEEL IN CONTACT WITH CHART
AUTOMATIC OPERATION
BALANCING MOTOR FREE 1.26
.07
.10
BALANCING MOTOR LOCKED .37
.20
PRINT-WHEEL IN CONTACT WITH CHART
PUSH-BUTTON OPERATION

Fig. 6. Sequence of operations—Numbers in circle diagrams give time in seconds.

Automatic Range-Changing is accomplished in the following way:

Each one of the seven banks of 20 couples may be associated with a different network to provide a different recorder range for each bank, or several of the banks may be connected to provide the same range while the remaining bank or banks may be connected to provide another range. For instance, if most couples were to be copper-copnic for measuring in the range of −100°F. to +700°F., the first six banks would be associated with that range on the recorder and the seventh bank would be associated with the range of 1050 to 2000°F., calibrated for chromel-alumel couples. In that case, as part of the automatic cycling operation, the range remains unchanged when switching between banks until bank No. 7 is reached and then is changed automatically. When bank No. 7 has been recorded and the recorder is switched to another bank, the range automatically changes back to the lower one. The automatic range-changing applies also to push-button operation.

Automatic Reference-junction Compensation. The fourteen plug-connectors (see Fig. 3) which bring the thermocouple leads to the switch-box connect to fourteen receptacles built into a "thermal equilibrium" chamber in the top of the switch-box, which keeps all of the reference junctions at the same temperature (regardless of what that temperature may be) and houses one or more resistance type automatic compensators for this reference-junction temperature.

Bank Identification. The numerals 1 to 7 inclusive, at the left of the chart, Fig. 7, are used for bank identification. Each of these points occupies a specific position on the chart. The fact that each of these identification markings appears in its own particular position on the chart verifies that there is complete synchronization between switching and printing mechanisms.

The bank identification is accomplished in the following manner: On bank No. 1 there is no thermocouple connected to the No. 1 switch-point. Instead this switch-point is connected to an electrical network so arranged that the recorder print-wheel prints No. 1 at a specific location on the chart assigned for the identification of the No. 1 bank. Likewise, in bank No. 2 there is no thermocouple connected to the No. 2 point on the switch, the connections to the No. 2 point again being made to a network which causes the recorder print-wheel to print the numeral 2 at a place on the chart specifically assigned for the identification of the No. 2 bank; and so on for all seven banks.

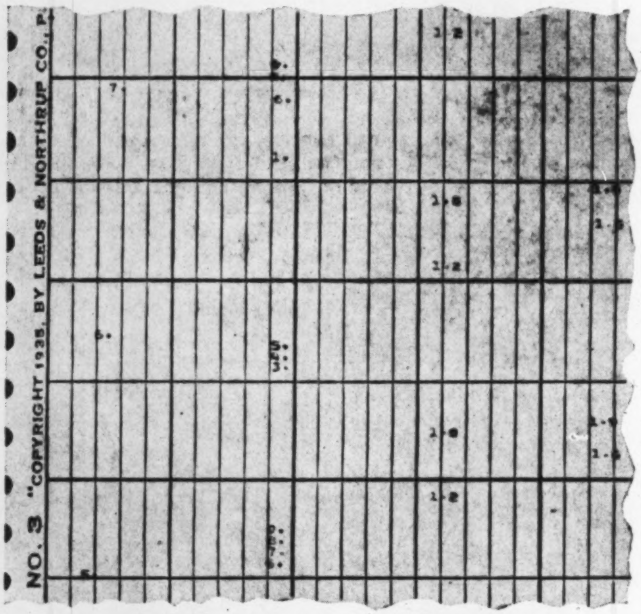


Fig. 7. Portion of recorder chart, approx. actual size. The 8" section of the 11"-scale-width 12"-paper-width chart, which is discussed in detail in the full text, is larger than this page. However, the small portion here reproduced includes three of the seven "Bank Identification" points and close examination suffices to bring out the "particular positions" explained in the abstract.

Push-button Operation. When the stepping switches are operated by push-button, there is an advance of one position for each operation of the button.

Obviously, when the switches are operated by push-button all synchronization between the switching and the recorder printing is lost so that when the control of the switching is returned to the recorder mechanism, some provision must be made to resynchronize the switching and printing. This is accomplished by an electrical interlock between the print-wheel and the automatic selector-switch advancing mechanism. Under automatic operation the selector-switches are always started from the No. 1 position and by means of the interlock the switching is not allowed to start until the print wheel is ready to print the numeral "1." By itself this simple interlock feature is not entirely satisfactory because even though the first active selector switch were thus synchronized, the remaining ones might be out of synchronism because of having been left in random positions as the result of push-buton operation. Of course, after a full cycle, involving the automatic operation of all seven selector-switches, the synchronization would be complete, but this might require 4 min. which is much too long. This delay is overcome by causing all selector switches to "clear" automatically at the time the switching control is transferred from "push-button" to "automatic." The "clearing" operation sends all selector switches to their No. 1 positions in a maximum of 6 sec. Automatic synchronization of the print wheel, which follows immediately, requires a maximum of 34 sec., so that total time for complete synchronization varies from less than 1 sec. to a maximum of 40 sec.

Under push-button operation, the selector switches are stepped quickly from one couple to another without waiting for the recorder to balance and print. Hence, the recorder might be attempting to rebalance at the instant the print wheel was in contact with the paper, causing damage. This problem was met by interlocking the balancing motor with the print wheel, so that when the print wheel is in contact with the chart the balancing motor cannot operate. This interlock is unnecessary during automatic operation from the recorder. See Fig. 6, diagram marked "push-button."

Grounding of Thermocouples. In some applications the couples are not in contact with metallic structures; in others they are. It was necessary to arrange the measuring circuits so that satisfactory operation could be obtained under either condition.

OPERATING EXPERIENCE

During the many months involved in the development of the recorder the selector switches were subjected to many thousands of operations and not a single failure was recorded. The automatic compensator for reference-junction temperature was subjected to ambient temperatures as low as 0°F. and no error outside the tolerance claimed for the instrument was observed. There is a lag of one hour between the time a temperature change is made at the exterior and the time when one-half of such change is effected in the interior of the "equilibrium chamber." This high degree of lagging is a fairly reliable indication that ambient temperatures lower than 0°F. will not cause appreciable error under expected service conditions.

In actual flight service at altitudes to 35,000 feet, the ambient temperature at the recorder was as low as −20°F. and this did not appear to affect the instrument operation. Accelerations caused no apparent effect on any part of the instrument.

AVAILABILITY. This new recorder is not now in commercial production and is available only in limited quantity for very urgent war problems.

The Application of Laboratory Test Data to New Design

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By R. G. ANDERSON
Aluminum Company of America, Cleveland, Ohio

This paper deals with the application of published mechanical properties of material to new designs. There exists a lack of understanding in the engineering profession regarding the procedure followed in obtaining these properties and the scope of their application. The published properties of material must be considered as the ultimate properties as they have been obtained from test specimens ideally produced. The data obtained from these test specimens have little bearing on the mechanical characteristics of machine parts made from the same material and given the same heat treatment due to irregularities in design, fabrication, application, etc. The size of specimen and type of fatigue test has direct influence upon the fatigue strength of a material. A brief outline showing limitations of properties obtained on laboratory test specimens is given in order to show why these properties cannot be applied in new designs without correction factor. The effect of elevated temperature on the mechanical properties together with the stress redistribution due to elevated temperature is shown.

An allowable working stress range diagram is given for aluminum alloys. The shape of this diagram can be obtained by means of a direct stress fatigue testing machine.

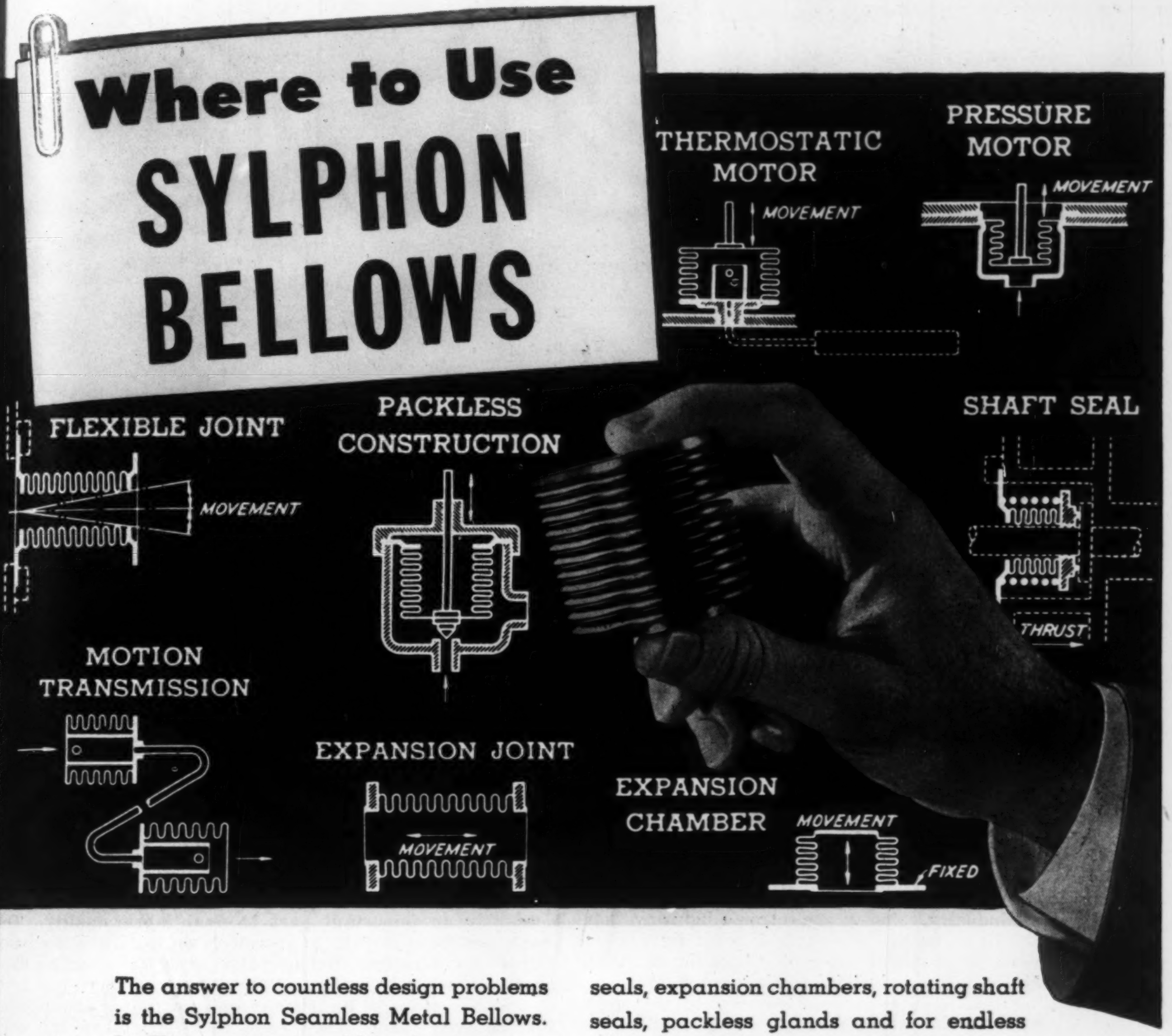
From experience with actual machine parts, we must conclude that stress calculations by text-book methods are wholly inadequate unless we make due allowance by the use of some rough empirical correction factors found by experience.

Fatigue tests on full-scale machine parts which have been properly organized reveal fundamental information and evaluate material design, and process of manufacture. The present practice of designing to large factors of safety is justified where the number of units produced is small. Where cost and weight is all-important, parts of machines should be designed with accurate knowledge of the strength.

Stress analysis of the part together with full-scale fatigue testing is productive of low cost and low weight.

While this paper pertains primarily to aluminum alloy, the analogy holds for other materials in most cases.

Where to Use SYLPHON BELLOWS


THERMOSTATIC MOTOR
MOVEMENT
PRESSURE MOTOR
MOVEMENT
FLEXIBLE JOINT
MOVEMENT
PACKLESS CONSTRUCTION
SHAFT SEAL
THRUST
MOTION TRANSMISSION
EXPANSION JOINT
MOVEMENT
EXPANSION CHAMBER
MOVEMENT
FIXED

The answer to countless design problems is the Sylphon Seamless Metal Bellows. In Thermostat assemblies, for instance, this amazing Sylphon Bellows helps solve the problems of temperature control in internal combustion engines, diesels, refrigeration and air conditioning, heating and ventilating, and many phases of industrial processing.

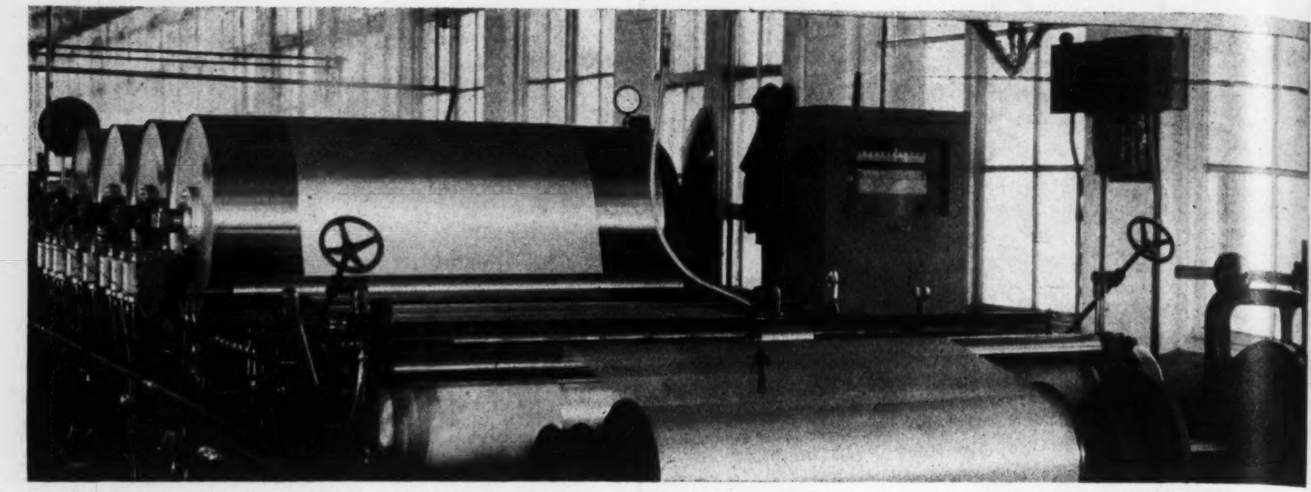
As highly efficient diaphragms used to convert pressure effects into controlled movement in instruments, appliances and machines of various types . . . as flexible seals, expansion chambers, rotating shaft seals, packless glands and for endless similar purposes, the Sylphon Seamless Metal Bellows is constantly replacing less durable, less dependable materials in the products of leading manufacturers.

Sylphon Bellows were pioneered 40 years ago by The Fulton Sylphon Co. And they have been first choice of American Industry ever since. Write today for Bulletin XX-535 which offers many suggestions for the designing engineer.

ARMY E NAVY

THE FULTON SYLPHON CO.
KNOXVILLE, TENNESSEE

Temperature Controls . . . Bellows . . . Bellows Assemblies



Application of the "Moist-o-graph" to slasher at Gilt Edge Textile Mills, New Bedford, Mass. Note small moisture roll over yarn beam.

Electronic Instrumentation in the Textile Industry

By STEPHEN T. HERR, Providence, R. I., Branch of The Brown Instrument Co.

THE title of this paper is meant to convey the idea that we are to discuss the application of electronic instruments to the machines and processes of the Textile Industry. It does not mean that we are going to delve into the details of electronics as a science.

When the present war is over, we anticipate the application of many proven electronic principles to industrial devices that feel, see, count, hear, inspect, record and control heat, light, time, and power. They promise the ultimate in labor-saving devices, performing hundreds of routine jobs and others for which human senses are too slow. The war has precipitated the development of electronic devices, and to a large extent it will have paid for them so that the resultant post-war devices will actually be a by-product of a war-depleted industry. The vast electronic industry that has been built up in recent years might never have been achieved, even in the minds of the most optimistic, if it had to depend entirely on the industrial market.

Although we are looking forward eagerly to this new Era of Electronics, we do not mean to imply that all of this is totally new. Some of it will simply be an improvement of design, or availability, of units that have already been introduced to a limited extent in industry. Because the future is so strictly veiled in military secrecy, it will be necessary for us to limit our present discussion to the latter classification with the hope that these will serve as examples of greater things to come.

One of the most widely adapted of the electronic principles to the Textile Industry is the phototube—a vacuum tube whose grid element is responsive to a ray of light. Any interruption or variation in the source of light changes the flow of electrons in the tube and thus permits its application to countless measuring and control devices. One such application is the spectrophotometer which can accurately distinguish two million shades of color and automatically record them on a color graph. Used as a control of color shades in textile dyeing, it has great possibilities.

Another photoelectric device that has had only limited application to date is an automatic weft straightener. This unit may be applied to tenter dryers where the fabric is of such a nature that the weft threads must be kept straight as a quality requirement. In order for an operator to do this, the tenter must not run at a speed greater than the limits of his own vision, and even then it is a difficult and nerve-trying task. With automatic weft straightening control, the phototube scans the individual weft threads with incredible speed and precision: 7000 threads per second in a fabric having 80 weft threads per inch and running at the rate of 140 yards per minute—and this is by no means the maximum.

Inexpensive photoelectric switches have been purchased by the thousands and applied by individual mill men in accordance with their own imaginative ingenuity to dozens of inspection, limit, and safety control tasks that have been to the decided advantage of all concerned.

In considering the application of electronic instruments to the Textile Industry, perhaps the most important field will be in the measurement and control of moisture. Moisture content of yarns and fabrics is a prime consideration of all textile manufacturers, and the frequent dampening and drying to which the materials are subjected can and does play an important part in final fabric quality. Too much moisture is just as harmful as too little in many stages of production. But manufacturers have had no happy choice between "wet" and "dry" because there has been no reliable means of measuring and controlling the distinction between them. They have therefore taken the only course open to them, which is to adjust machine speeds and temperatures at such values as to assure sufficient drying, even though this may be done at the expense of quality, efficiency and production.

Electronic instrumentation offers certain relief to this blind spot in textile manufacture in the form of instruments which are capable of continuous measurement and control of moisture content in cotton and rayon materials. Such instruments are equally well adapted to any type of dryer, but I believe it will serve our purpose best if we select one type of dryer as an example. A cotton slasher is a good subject, for it is the first dryer in the chain and can therefore be responsible for final fabric quality regardless of any subsequent processes. The purpose of a slasher is to provide a mechanical protection for the warp threads against the stresses of weaving. To accomplish this the warp is impregnated with a starch and oil solution, known as size, and then passed over steam-heated cylinders for drying. The amount of moisture left in these warps determines their strength and pliability, and therefore the efficiency with which they may be woven. The most important variables that affect the rate of drying are:

1. Surface temperature of drying cylinders.
2. Speed of yarn travel over cylinders.
3. Weight of the warp being dried.
4. Depth, and therefore time, of immersion of warp in size.
5. Temperature, and therefore viscosity, of size solution.
6. Ambient temperature, humidity and air motion.

Automatic control of five of these six variables has been available for a good many years, and most mills have con-

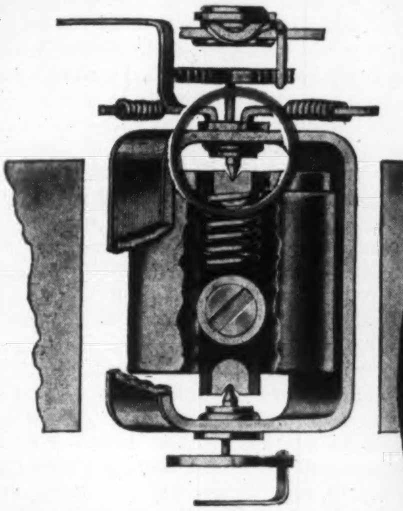
---

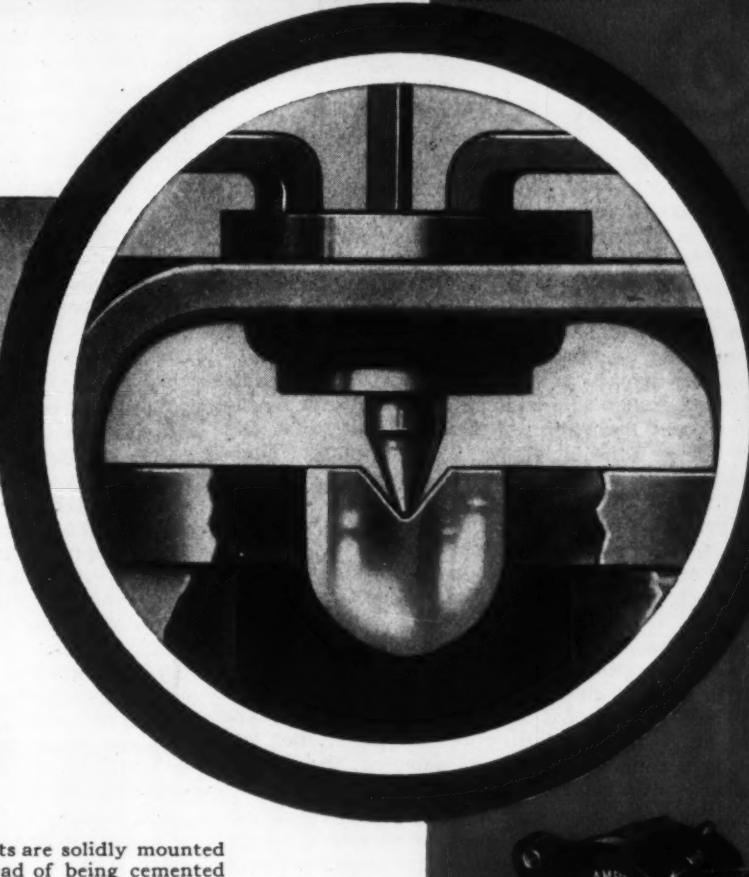
EXTENDED ABSTRACT of paper presented at Annual Meeting, New York, Nov. 28-Dec. 3, 1943, of A.S.M.E., under auspices of Textile Division.

New INTERNAL-PIVOT ELECTRIC INSTRUMENTS

2½-inch - - - 1 inch deep

For radio and other communications service; d-c voltmeters, ammeters, milliammeters, microammeters, and radio-frequency ammeters and milliammeters (a-c thermocouple type). Cases are brass or molded Textolite.





(Above) The new internal-pivot bearing construction. (Right) Top bearing (pivot and jewel) magnified 20 times. Note strong, solid construction.

WHY THIS BEARING CONSTRUCTION INSURES LONG-TIME SERVICE . . .

IN THESE new G-E instruments, the pivots are solidly mounted on the *inside* of the armature shell instead of being cemented to the outside of the armature winding. The result is a rigid construction that helps to maintain accurate alignment.

The steel pivots, highly polished, are of the aircraft type, larger than normal. This means less stress on the bearing surfaces and a construction that will stand rough treatment and shock.

The pivots rotate in low-friction, highly polished, glass vee jewels—one mounted rigidly in the top of the frame-and-core assembly, and the other mounted in a movable lower jewel sleeve located in the soft-iron core.

This combination—accurately formed, hard-glass jewels and large-radius steel pivots—provides a co-ordinated bearing that has proved, by field tests, to be excellent from the standpoint of long life and ability to withstand vibration.

Thin, Strong, Accurate Instruments

1. *Thinness* is obtained by solidly mounting the pivots on the inside of the armature shell. Most instruments are approximately one inch deep.
2. *Strength* is obtained by short, solidly mounted, large-radius pivots and the extra-strong over-all case.
3. *Sustained Accuracy* is insured by the featherweight moving element, combined with high torque and permanent alignment of all parts.

For ratings, prices, and dimensions, ask our nearest office for Bulletin GEA-4064, which covers instruments for use in radio and communications equipment; or Bulletin GEA-4117, which describes those suitable for naval aircraft. *General Electric Co., Schenectady, N. Y.*

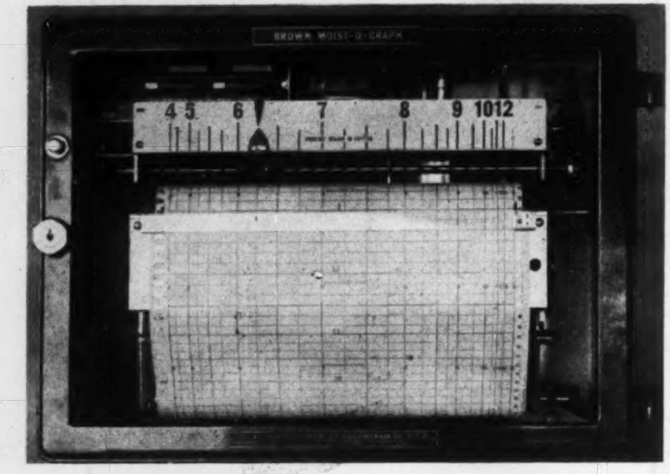
GENERAL ELECTRIC

602-44-62[illegible]

AMPS
60 40 20 0 20 40
VOLTS
25 10 10 25

D-c voltmeters, volt-ammeters and ammeters are specially designed to measure voltage and current in battery and battery-charging circuits on naval aircraft. They meet applicable Navy specifications.

SMALL PANEL INSTRUMENTS



The Brown Instrument Co.'s "Moist-o-graph."

trolled some or all of them. But the sixth one, relating to air temperature, humidity, and motion surrounding the warps, has remained uncontrolled and unpredictable until recently. And in the meantime, in spite of the considerable aid given by laboratory and instrument control of some variables, moisture content of the warps has remained as elusive and uncontrolled as ever. Elaborate schedules of temperature and speed for a given weight of warp have been established by laboratory test as standards by which moisture content may be predicted. But such a schedule established on a sunny afternoon in June may not be dependable that same night, or the next day if it rains, and it certainly will be unreliable the following winter. Thorough temperature-speed-weight schedules require so many "ifs" depending on the weather that simplified schedules designed to produce safely dry warps under the worst conditions have been accepted as general practice. The warps thus produced seldom have more than 4% of moisture and must therefore be further conditioned before they may be woven with any degree of efficiency. This conditioning is accomplished with a humidifying system in the weave room which, in a cotton mill, maintains tropical temperatures with which to hold in suspension relative humidities that range up to 85%. Subjected to this damp fog, the warps regain some of the moisture they lost on the slasher and although it is a roundabout way of doing it, the net result is generally satisfactory.

From what has just been said it must be apparent that although a slasher may be designed to condition warps, the limitations of human judgment require that it actually be used as a dryer. And because it is used as a dryer we have several attendant evils which combine to increase the production cost per yard of greigh goods. Slow and "safe" slasher speeds produce fewer pounds of warp per pound of steam, per man hour, and per machine hour than the theoretical speeds at which the slasher could be run if the danger of wet warps could be avoided. Expensive repairs to woodwork and machinery in the weave room, due to excessive condensation of humidity-laden air, could be greatly reduced if the humidifying system could be relieved of its pumping duties and serve simply to maintain warp conditions established on the slasher. Because these conditions exist and are fully recognized, various instrument manufacturers have accepted the challenge of mill men to do something really constructive about it. Several direct-reading moisture controls have been offered as a solution to this problem but the Moist-o-graph, built by the Brown Instrument Co., has met with the widest general acceptance.

The Moist-o-graph employs an electronic circuit which permits this unit to measure extremely high electrical resistance values accurately and consistently. Exhaustive tests by independent authorities have established the fact that a definite relationship exists between electrical resistance and moisture content of a variety of materials, including cotton and rayon. It has therefore been possible to calibrate the Moist-o-graph in terms of percent of moisture and thus provide a new tool for the direct measurement and control of this previously elusive factor. When applied to a slasher, a small metal contact roll rides on the warp at the delivery end of the machine. The grid element of the measuring circuit is connected to this control roll and it is responsive to the current which can be passed through the warp from an independent low-voltage source. The current which passes through is a measure of the electrical resistance, and therefore moisture content, of the warp. These currents are extremely small but they are as readily detected in this unit as similar energy waves are detected in a radio receiver, and in the same manner are amplified and put to useful work. By providing the instruments with a set of control contacts, and the slasher with a suitable variable-speed drive, it is then possible to set the control point at any desired moisture content and the unit will automatically maintain this value by adjusting slasher speeds as required. In order to obtain maximum benefit from the Moist-o-graph it is recommended that size preparation, size box temperature and level, and cylinder temperature or pressure should all be under automatic control. The Moist-o-graph then acts in the capacity it was designed for, which is to compensate by speed corrections for the unpredictable variations that cannot otherwise be controlled. Warps may then be produced with a uniformly high percent of moisture at slasher speeds that are limited only by their mechanical ability to function efficiently at high speed levels. The conditioned warps thus produced have maximum strength and flexibility; they will weave with maximum efficiency at greatly reduced atmospheric humidity; and are delivered to the finisher as a soft and pliable fabric in ideal condition for further processing.

We could perhaps follow the greigh goods we have just processed into the wet and dry finishing mills, and by applying the Moist-o-graph to tenters, can dryers, loop dryers, callenders, etc., we could perhaps further demonstrate production, quality and efficiency benefits. But this would simply by a repetition of the point I have tried to make, which is that moisture requirements have been a retarding factor in the manufacture of textiles, and electronic instruments now available point the way to a revision of our current sense of values and ideals. I say that these developments point the way to a solution of our problems, rather than say they are the solution, because their successful application largely depends upon the characteristics of the machines and processes to which they are applied. A 2000-hp. airplane motor geared up to the wheels of an ice wagon is certainly a ridiculous application of potential energy available. But if we streamline the wagon, and put wings on it, we may then obtain full benefit from the engine. In a somewhat lesser degree, electronic instruments and devices may be compared to much of our present process machinery, and the promised miracles of electronics cannot become universally available until industry and machines are revised to accommodate them.

ELECTRONIC DEMONSTRATION

[*An instrument exhibit was set up and Mr. Herr explained the operating principles. The following is a brief summary of some of his remarks.*]

Electronic circuits have been applied to the pyrometer; the galvanometer has been replaced by a vacuum tube; and the useful measuring field of the thermocouple now extends from top to bottom of all known degrees of heat and cold. This development not only permits the application of the rugged simplicity and flexibility of a pyrometer system to the low-temperature fields, it also brings a new high order of precision and speed of measurement which is characteristic of all electronic devices.

Although the advantages of this electronic measuring system over the conventional thermometer are multi-dimensional, and its application is practical in many low-temperature processes, its universal application is still governed by the limitations of men and machines. It is therefore something for tomorrow, rather than today, but it is nevertheless an example of the kind of development the Era of Electronics will produce.

Instrumentation in the Textile Industry

By **W. B. HEINZ, Consulting Engineer, Bound Brook, N. J. (representing the Cochrane Corp., Philadelphia, Pa.)
and W. W. STARKE, Assistant Plant Engineer, Forstmann Woolen Co., Passaic, N. J.**

TABLE I—OBJECTIVES FOR INSTRUMENTATION IN TYPICAL TEXTILE OPERATIONS

	SUPERVISORY OBJECTIVES				CONSERVATION OBJECTIVES		
Operation	Kind of Measuring Instrument or Control	Quality Maintenance	Capacity	Manpower	Material	Steam, Water, Electricity	Other Objectives
DYEING Dye Liquor	Automatic Temperature Control and Indication	Duplicate standard conditions	Reduce waste time in adjustment of temperature	Reduce operating attention	Reduce deterioration	Reduce excess heating	Reduce boiling over hazard, Operational record
Dye Liquor	Pressure Indication	Duplicate standard conditions	Indicate pump shortcomings	—	Reduce deterioration	—	—
Dyeing Temperature cycle	Automatic Time Cycle Control	Duplicate standard conditions	Reduce excess time	Reduce operating attention	Reduce deterioration	Reduce excess operation	—
Dyeing Liquor Flow Cycle	Automatic Flow Reversing Control	Duplicate standard conditions	Reduce excess time	Reduce operating attention	Reduce deterioration	Reduce excess operation	—
Preheated Water Supply	Automatic Temperature Control	Duplicate heating cycle in machine	Reduce heating time in machine	—	—	—	—
Water Supply	Pressure Indication	—	Indicate supply shortcomings	Reduce machine filling time	—	—	—
Water Supply	Meter	—	Indicate excessive demands	—	—	Check operating economy	Costing record
Steam Supply	Pressure Indication	—	Idicate supply shortcomings	Reduce heating time	—	—	—
Steam Supply	Meter	—	Indicate excessive demands	—	—	Check operating economy	Costing record
DRYING Air Temperature	Automatic Control or Indication	Avoid over temperatures	Avoid under temperatures	Reduce operating attention	Reduce possibility of material damage	Avoid overheating	—
Humidity of Drying Air	Auto. Control of Make-up Air or Indication of Humidity in Dryer	Maintain optimum conditions	Permit higher feed and temperature and avoid excessive makeup air	Reduce operating attention	Reduce possibility of material damage	Avoid heating up excessive makeup air	—
Rate of Travel of Material	Auto Control or Indication of Conveyor Speed	Avoid overdrying	Adjust to most efficient speed	Reduce operating attention	Reduce possibility of material damage	Savings by efficient operation	—
Moisture Content of Delivered Material	Moisture Indication or Control	Avoid over or under drying	Adjust to most efficient operation	Reduce operating attention	Reduce possibility of material deterioration	Savings by efficient operation	—
Air Circulation	Manometer	—	Maintain full air flow	Indicates clogged screens	—	Savings by efficient operation	—
Steam Supply	Pressure Indication	—	Indicate supply shortcomings	—	—	—	—
RING SPINNING Room Conditions	Automatic Temperature Control and Indication	Maintain correct temp. for fiber workability	Reduce breakage anu permit higher rate of operation	More production per worker. Save hand control of humidity	Reduce waste	Reduce excess heating	—
Room Conditions	Automatic Humidity Control and Indication	Reduce effect of static electricity	Reduce breakage and permit higher rate of operation	More production per worker. Save hand control of heating	Reduce waste	Reduce excess heating	—
Machine Speed	Antomatic Control and Indication	Operate at correct speed for yarn and bobbin winding	Operate at maximum speed for yarn and bobbin winding	More production per worker	—	—	—

MEASURING instruments and automatic controls are becoming recognized as essential. However, casual choice of this type of equipment can result in expensive misapplications. Skillful selection and application of measuring instruments and automatic controls requires careful analysis. Questions such as the following should be clearly answered:

1. Objectives—What long-term instrumentation program is being followed? What is to be accomplished, and how important are the results?

2. Measurements—What condition is to be measured for regulation, either manually or automatically? This is the controlled variable.

3. Degree of Instrumentation Required—Is an indication sufficient, or does the operation require a record? Is manual control dependable enough, or does the job need to be done better than a man can do it?

4. Mode of Control Required—On-off, proportional, or automatic reset?

5. Power Medium—What is the most desirable kind?

6. Special Conditions—Are there any unusual factors influencing selection?

[The authors discuss fully each of these steps. Their paper runs to about 7000 words. The following consists of some almost-verbatim quotations, but only from the sections of interest to all industries, it being impracticable to abstract the other sections. However, Table I, which summarizes one of their analyses, is reproduced without condensation.—ABSTRACTOR.]

In order to gain the maximum profit from instrumentation, it is necessary to establish a comprehensive policy for the entire mill. The first step is a survey of existing operations and existing instrumentation, noting particularly their respective conditions and limitations. Working from this survey, a master instrument and control schedule is developed to fill in the gaps, to provide additions where justified, and to program needed rehabilitations and replacements.

Such a plan should include schedules for periodic servicing and calibration under the supervision of a central group. The individual production operator is prone to be content with an instrument as long as the pointer moves and there are no obvious production faults. Since a miscalibrated instrument can readily cause a constant opera-

---

EXTENDED ABSTRACT of paper presented at Annual Meeting, New York, Nov. 28-Dec. 3, 1943, of A.S.M.E., under auspices of Textile Division.

tional error, it is important that instruments be maintained in a reliable condition. Where the work is not sufficient to fully occupy one man, the selection of an individual for this work should consider his usefulness for related work such as testing and adjustment of dryers, supervision of steam, water and power distribution, air conditioning, or conservation work on these services. In fact, a key to a successful instrumentation program is a permanent organization unit to carry out this function and to coördinate allied work.

Several different conditions may vary during a process operation. It is important to identify the condition whose measurement gives the best guidance to an operator or the most effective actuation of an automatic controller. In a can dryer the thermal condition in each unit is indicated either by direct temperature measurement or by measurement of the steam pressure in the can. Although pressure measurement is simpler and cheaper, and pressure control is faster and more positive than temperature control, the measurement and control of temperature itself is not difficult. Since abnormal conditions, such as air inside a drum, can upset the normal relationship between temperature and pressure, direct measurement of temperature is often preferred.

A simple operating indicator such as a pressure gage, thermometer or speedometer is frequently sufficient. In operations where trends are simple and fluctuations are slow, occasional observation by the operator permits the necessary adjustment. In some cases secondary instrumentation by an indicator is installed for trouble shooting. For example, if heating cycles stretch out, a steam pressure gage on the main shows if the cause is low steam pressure.

Recorders are used on important or more complex operations where a historical record is desirable. A recorder is invaluable in connection with automatic control of a difficult process because of its aid in adjusting the controller. Recorders are particularly useful where measurements are constantly fluctuating and a correct average condition is to be maintained. On important operations they give the departmental supervisor a record of the performance of his operators and equipment, and in cases of production troubles they are useful in tracing causes.

Integrating instruments are of principal value for accounting records, such as steam, electricity or water consumption. Mechanical counters are a form of integrator useful for checking production and establishing piece work rates.

Modern recorder-controllers (or corresponding indicating controllers) include the most highly developed control mechanisms on the market. They should be used whenever the best control performance is wanted. Cost differences as compared with combinations of independent controllers and recorders are usually unimportant.

Where operations are critical, and where the primary or sensitive element is exposed to damage or corrosion, a separate indicator should be used as a check instrument. If a number of associated temperatures are to be checked, an indicating potentiometer wired to several thermocouples, or an indicating type of Wheatstone bridge wired to several resistance thermometers, provides convenient, low-cost service.

Variables are frequently controlled through the addition of control mechanisms to measuring apparatus. Such controls may be self-operating, employing energy furnished from the process itself; or they may be servo-operated, utilizing power from electricity or air, water and the like. Servo-operated controllers are always more sensitive and precise, and are substantially the same in reliability as self-operating devices. The trend is definitely toward more extensive use of servo controls.

Although an operator with an indicating instrument can perform some functions as well as an automatic controller, no operator can match modern instruments in repeating identical cycles, and in many continuous processes. A good recorder-controller will start corrective action *before* its own pen has started to move, and before an indicator will have made a readable response to guide an operator. However, good practice provides for manual operation also.

The use of automatic control is indicated in the following cases:

1. Regulating functions require almost constant attention.
2. Fluctuations are too rapid for manual control, or so slow and complicated that an operator cannot foresee what he must do for a future correction.
3. Regulating device is too large or requires too much power for manual control.
4. Lapse of operator's attention would cause substantial loss in quality or capacity.
5. Operating labor can be saved or lower grade operator can be used.
6. When control should be centralized.

TYPE OF CONTROL REQUIRED

The major technical requirements of a controller which determine the control action which it should provide are (1) Fast correction of a deviation in the controlled variable; and (2) Adequate stability. Needless to say, it must also be thoroughly reliable.

No simple procedure has yet been developed for making quantitative predictions of stability, except in the simplest situations.

Process properties, valve characteristics and controller adjustments—all determine the performance of the system. The process properties which influence control are of only four basic kinds: capacitance, resistance, dead-time and self-regulation. The numerous lags and capacities can all be reduced to various combinations of capacitances, resistances and dead-time. Self-regulation is an independent property.

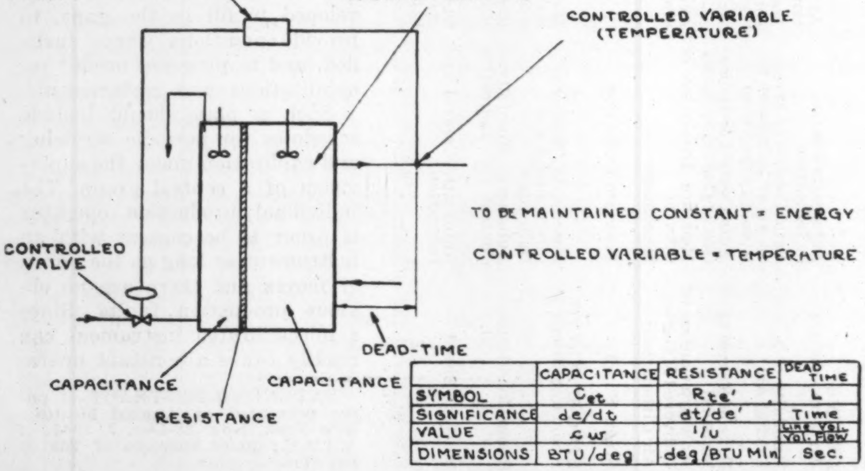
Fundamentally, every automatic control problem is one of regulating the transfer of energy or material. Temperature control usually involves the regulation of heat energy exchange; pH control deals with the transfer of materials, as does flow control. Pressure control is accomplished in some cases by heat exchange and in others by the exchange of materials. Speed control involves the transfer of mechanical energy.

The significance of the generalized properties which we term capacitance and resistance can be developed by reference to a standardized figure, suggested by the heat transfer analogy published by E. D. Haigler of Foxboro in 1938.

Fig. 1 shows a simple heat exchanger. A heat supply liquid enters at the bottom left, through a controlled valve, flows up through the supply side and out again. Heat from the supply side passes through a heat transfer surface into the demand side of the heat exchanger, through which flows the fluid whose temperature is being controlled.

The point where the temperature is measured by the controller is downstream from the demand side of the heat exchanger by an amount which determines the dead-time between a change in the demand-side temperature and the sensing of it by the controller bulb. We have here supply-side capacitance, demand-side capacitance and

FIG. 1



	CAPACITANCE	RESISTANCE	DEAD TIME
SYMBOL	C_{et}	$R_{te'}$	L
SIGNIFICANCE	de/dt	dt/de'	Time
VALUE	cw	1/u	Line Vol. Vol. Flow
DIMENSIONS	BTU/deg	deg/BTU Min	Sec.

dead-time. This process also possesses self-regulation.

An analogous situation is illustrated in Fig. 2. The process here takes the form of a hydraulic system wherein the volume, weight or stored energy in the demand side is to be controlled by means of an instrument which is here shown responsive to the pressure at the bottom of the demand side column of liquid. The process capacitances, resistances and dead-time are directly analogous to the previous heat transfer case. However, the dead-time is negligibly short, it being only the infinitesimal period required for a pressure wave to propagate from the tank to the controller. This process also possesses self-regulation.

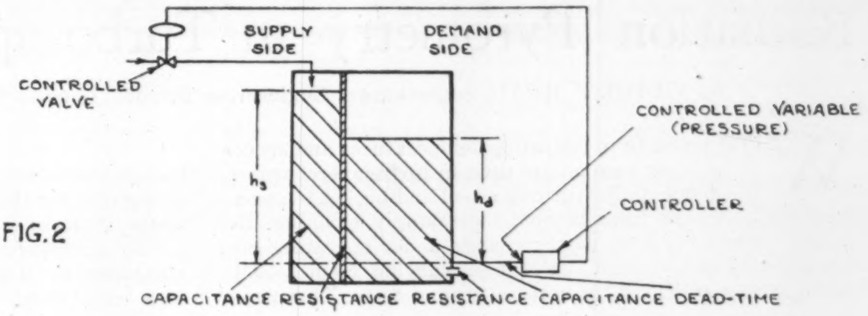


FIG. 2

Fig. 3 illustrates self-regulation. The first tank is self-regulating. If the controller were not working and the inflow were too great, the head would increase until the outflow through the exit orifice would equal the inflow. The second process possesses no self-regulation. The out-flow, being handled by a positive-displacement pump, is not affected by the head. In the absence of control, any slight deviation in the inflow from equality with the outflow will produce a continuing change in the level.

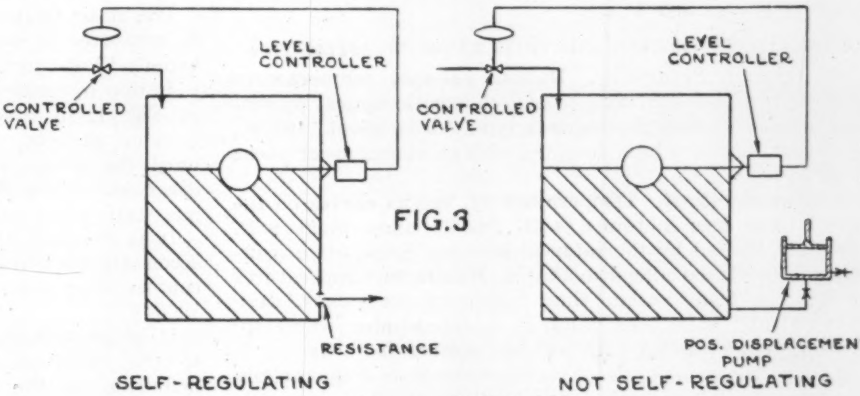


FIG. 3

SELF-REGULATING

NOT SELF-REGULATING

The foregoing are the basic properties of all processes which must be considered in analyzing or judging controllability. There has as yet appeared no tool-box method for quick and easy advance determination of the control behavior of a process, except the simplest types. By reference to the next few figures we can review typical combinations of process properties which make for ease or difficulty in control.

Fig. 4 shows the heat exchanger process again, all properties being arranged to make control easy. Its supply-side capacitance is small; the resistance is small; the demand-side capacitance is large; there is no dead-time between the demand side and the bulb; and the bulb capacitance and resistance are both negligible. Temperature control in an open water tank provides an example, particularly if the water is heated by direct steam injection. Another case is control of water level by means of a float type controller. A third example is temperature control in a steam-heated dryer with good air circulation and good heater and bulb characteristics.

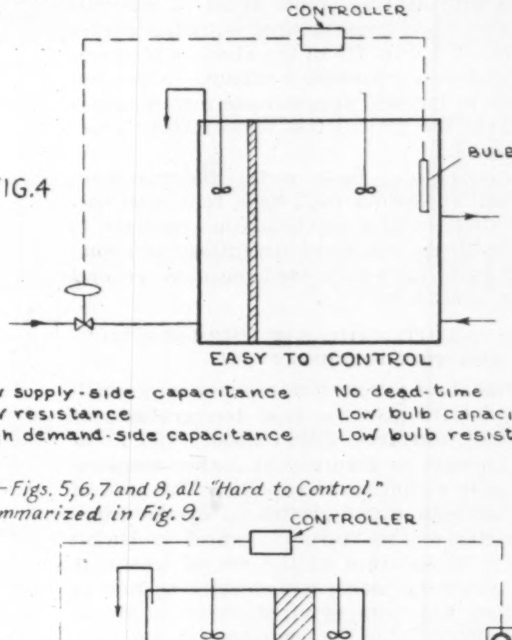


FIG. 4

EASY TO CONTROL

Low supply-side capacitance
Low resistance
High demand-side capacitance
No dead-time
Low bulb capacitance
Low bulb resistance

NOTE – Figs. 5, 6, 7 and 8, all "Hard to Control," are summarized in Fig. 9.

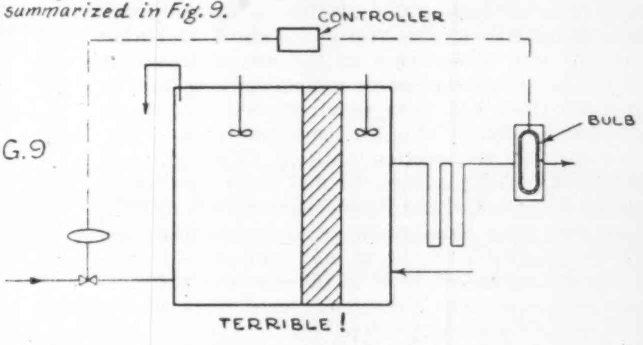


FIG. 9

TERRIBLE!

High supply-side capacitance
High resistance
Low demand-side capacitance
High dead-time
High bulb resistance
High bulb capacitance

If we shift the partition to the right as in Fig. 5, we make the process more difficult to control. The supply-side capacitance has become large and the demand-side small. A typical example is temperature control in an open heater tank heated by a steam coil of excessive heat storage capacity. It should be recognized that temperature control in a storage type water heater (a shell around a steam coil) is often erratic on account of the absence of stirring to maintain uniform conditions.

In Fig. 6 the resistance has been increased, thus making the process more difficult to control. An example is temperature control in a jacketed size kettle heated by hot water in the jacket.

In Fig. 7, the identical process has been made difficult to control by the introduction of a bulb of high capacitance, and with high resistance around it.

Fig. 8 illustrates the manner in which dead-time makes control difficult. Here, the process has been changed only by moving the bulb downstream. A large dead-time has been introduced. A continuous steam-to-liquid heat exchanger is an example, with liquid flowing through a coil in a large steam space. In such a heat exchanger, a temperature-responsive bulb at the coil outlet does not get the full effect of a change until time enough has elapsed for liquid to flow the full length of the coil.

Finally, we have everything gone wrong! (Fig. 9). The supply-side capacitance is large, the transfer resistance extreme, the demand-side capacitance small, large dead-time, and a bulb installation which includes all the bad features.

(Concluded on page 76)

Radiation Pyrometry in Turbosupercharger Testing

By VICTOR P. HEAD, Supercharger Engineering Division, General Electric Co., West Lynn, Mass.

WITH increase in operating temperatures and speeds of turbines such as are used in turbosuperchargers, the demands for turbine wheel and bucket temperature measurement have become increasingly exacting. Requests appear for such measurements under operating conditions with measurement tolerances varying from ±50°F. in flight test to ±5°F. in certain ground tests. This paper outlines the procedures used for measurements ranging from as low as 300°F. up.

ALTERNATE PROCEDURES AND THEIR RANGE OF APPLICATION

1. Optical Pyrometry. Bucket hot-spot temperatures have been determined with a monochromatic optical pyrometer of the disappearing-filament type. Above about 1400°F., such readings have been accepted with an allowance of about ±30°F.

2. Fusible alloys. Temperature vs. radius curves on the wheel have been obtained with fusible alloy plugs with accuracy limited by the interval between consecutive melting points of the alloys available. Maximum temperatures during the tests, rather than instantaneous values, were obtained and have been valuable in determining wheel operating temperatures with various cooling methods.

3. Fusible compounds. Fusible compounds commercially available as pellets with melting points at 50°F. intervals have been used to give wheel temperatures vs. radius curves with a probable error of 1% or 2% of the absolute temperature. Again the indications represent maximum values, but the pellets are made to indicate approximate instantaneous values by approaching the desired test temperatures gradually with no overshoot.

4. Contact thermocouples. Base metal thermocouples peened into the wheel at various radii have been used successfully with slip-rings to give instantaneous readings in comparing cooling methods, but speed limitations and complexity of rotating parts have prevented the more general application of this procedure.

GENERAL METHODS AND APPLICATIONS OF THERMOELECTRIC RADIATION PYROMETRY

Thermoelectric radiation pyrometers commercially available have been applied to give the local temperatures at wheel rim and bucket surfaces within about ±50°F. at 1000°F. and with increase in accuracy at higher temperatures, by appropriately mounting and cooling. The area of the spot observed has been varied arbitrarily by the proximity of the pyrometer to the "target" (wheel or bucket surface) or the size of aperture or the use of lenses. A knowledge of the pyrometer jacket temperature as well as the pyrometer output has been required, and the use of a cooled shutter for determining the magnitude of the "zero drift" (described in the section entitled "Theory") has helped to facilitate the readings. In flight tests conducted by the General Electric Co. and Boeing Aircraft Co. in 1941, adequate results were obtained by scooping atmospheric air to cool the pyrometer mounting and prevent soot accumulation, where a spread of 50°F. in the observed temperatures was permissible. The pyrometers used were of the glass-bulb vacuum thermocouple type (1)*.

APPLICATION OF PRECISION THERMOELECTRIC PYROMETERS

Thermoelectric pyrometers commercially available have been adapted to meet recent exacting demands for greater accuracy at lower temperatures. Calibration repeatability within ±5°F. over a range of temperatures from 600°F. up has been obtained. The inherent error of base-metal thermocouples used to measure the calibrating target temperatures has limited the absolute accuracy obtained.

Proper arrangement of an experimental miniature pyrometer has permitted instantaneous readings of wheel and bucket temperature during test, and is now being employed as a guide for the control of test conditions when arbitrary temperature-vs.-radius curves are desired.

The arrangement may be applied to the temperature measurement of gases and vapors by sighting into the end of a long "honey-comb" (2) in a well-lagged duct through which the gas may be passed.

The static temperature of hot gases at high velocity may be measured by replacing the optical pyrometer of Kurlbaum's Flame method (3) with a precision thermoelectric radiation pyrometer. One possible arrangement is suggested in Fig. 1, in which the manual adjustment of a single resistor permits variation of a background temperature until the actual and indicated background temperatures are equal, when the indicated temperature will be actual gas static temperature, regardless of gas emittance.

It is proposed that the arrangement may be used as a secondary standard in the calibration of base-metal thermocouples, thermometers, and the like, for temperatures above 1000°F.

It is conceivable that rigorous application of thermoelectric radiation pyrometry theory may permit sharper definition in the International Centigrade Temperature scale at elevated temperatures, reducing the spread entailed by the brightness-comparison methods of optical pyrometry, since the "readability" of the output increases

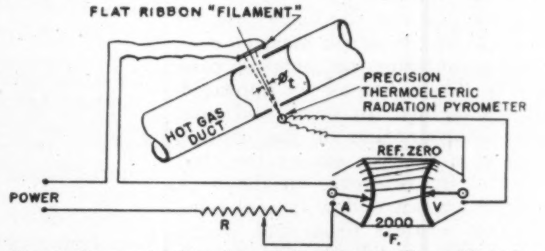


Fig. 1. Proposed adaptation of Kurlbaum's Flame Method to static temperature of high-velocity high-temperature gases not completely transparent.

A—Ammeter calibrated for filament temperature.

V—Galvanometer indicating filament temperature by thermoelectric radiation pyrometer output, calibrated with clean, dry cold air in duct.

R—Manual filament temperature control resistor.

ϕ—Pyrometer sight angle, completely subtended by filament surface.

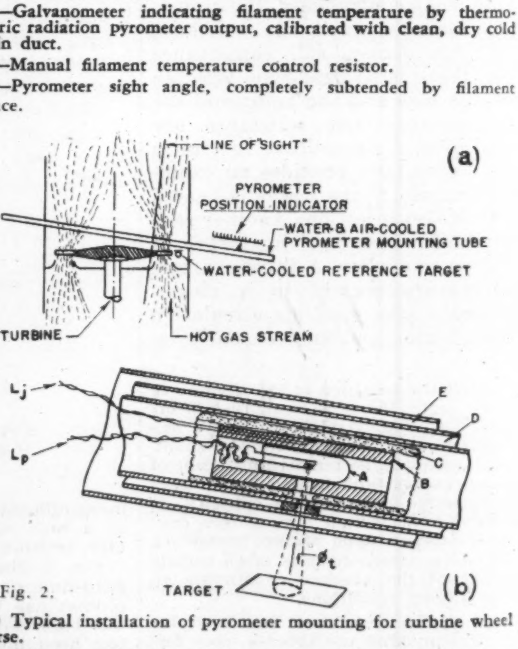

LINE OF "SIGHT"
(a)
PYROMETER POSITION INDICATOR
WATER & AIR-COOLED PYROMETER MOUNTING TUBE
WATER-COOLED REFERENCE TARGET
TURBINE
HOT GAS STREAM
L_j
L_p
E
D
C
B
A
ϕ_t
TARGET
(b)

Fig. 2.

(a) Typical installation of pyrometer mounting for turbine wheel traverse.

(b) Mounting arrangement for a commercial vacuum type pyrometer: A—Pyrometer; B—"Heat Mass" (extra-heavy pipe); C—Thermal insulation; D—Cooling water passage; E—Air passage; L_p—Pyrometer leads; L_j—Pyrometer jacket thermocouple leads; ϕ_t—Solid angle of sight.

FULL TEXT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Aviation and Industrial Instruments and Regulators Divisions.

*Numbers in parentheses refer to bibliography at end of paper.

with approximately the third power of the measured temperature.

An interesting application is the measurement of pressure at high vacuum, using a target of constant temperature such as a lamp with controlled voltage, and connecting the pyrometer chamber to the vacuum to be measured, as described further under "Tests."

ARRANGEMENTS

Fig. 2 shows the arrangement of a mounting used in a high-velocity hot-gas stream. The commercial pyrometer, an evacuated glass-bulb type, was wrapped in aluminum foil and encased in a heavy-walled tube of high thermal conductivity and high specific heat, which acted as a heat "fly wheel" to prevent sudden changes in pyrometer temperature. A thin layer of thermal insulating material supported the massive tube within a cylindrical water-cooled outer jacket. An additional jacket carrying air prevented soot accumulation at the sighting aperture. A water-cooled reference target permitted zero drift observation, and even with the best combination of heat capacity and thermal insulation, corrections amounting to several times the full-scale reading of the galvanometer were frequently required. For this purpose a zero-drift compensator was inserted in the pyrometer circuit, Fig. 3, so that by introducing the proper electromotive force, the galvanometer could be rapidly set to zero. The *reflection* of extraneous radiation from the surface of the reference target left this adjustment open to some question, and the necessity for the elimination of zero-drift, together with the need for reduced bulk in the pyrometer mounting led to the development of the miniature radiation pyrometer of Fig. 4.

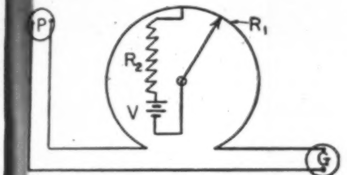


Fig. 3. Rapid zero-drift compensator for precision thermoelectric pyrometer circuit.
P—Pyrometer;
G—Galvanometer or potentiometer;
R_1—Low-resistance slide-wire;
R_2—High resistance;
V—Dry cell.

Fig. 4 shows the essential features of a thermoelectric radiation pyrometer embodying the theoretical requirements for precision. Tests conducted on a model of this type show that its repeatability is well within the limits of error of the base-metal thermocouples employed in calibrating. It has the further advantage of small size and self-contained "heat-capacity," so that the jacket required for mounting in a high-velocity hot-gas stream may be kept to a minimum bulk. The necessity for a cold reference target and zero-drift compensator has been eliminated.

Attempts to seal this model to hold a vacuum permanently have been unsuccessful to date, and the device is employed at atmospheric pressure. The sacrifice of high output has been largely offset by the relative freedom from changes in calibration with small changes in jacket temperature, a characteristic which is highly desirable. The output is read on a light-beam type galvanometer of portable construction having a full-scale deflection (100 mm) at about fifty microvolts. The characteristics of the pyrometer are such that a relatively small target temperature range is conveniently spread over the upper 90% of the scale range (Fig. 7, curve *b*). The use of a direct-reading galvanometer requires that there be no change in lead resistance between calibration and application, but no attempts to use a potentiometer have been successful. The time required to balance a potentiometer permitted inestimable zero-drift with the commercial high-output type pyrometer, and the readability of the potentiometers available has been inadequate for the miniature type.

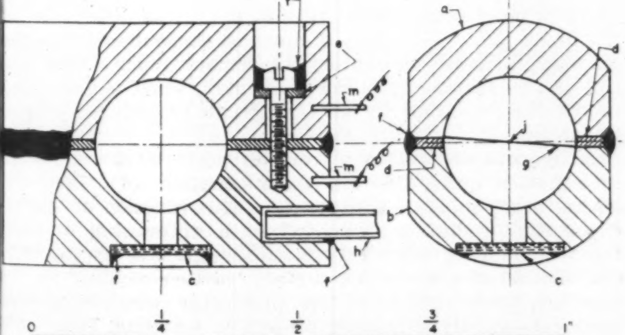


Fig. 4. Miniature radiation pyrometer embodying precision requirements.
a, b—Upper and lower half-jackets, serving also as thermal capacitance and electric conductors (commercially pure copper); c—Window glass, rock-salt, etc.; d, e—Electrical insulation; f—Sealing compound; g—Thermoelectric element with receiver and hot junction at center (j) and cold junctions at pyrometer walls; h—Glass evacuating and sealing tube; m—Pyrometer leads.
Not shown: Thermal insulation, outer cooled mounting, and sight limiting aperture.

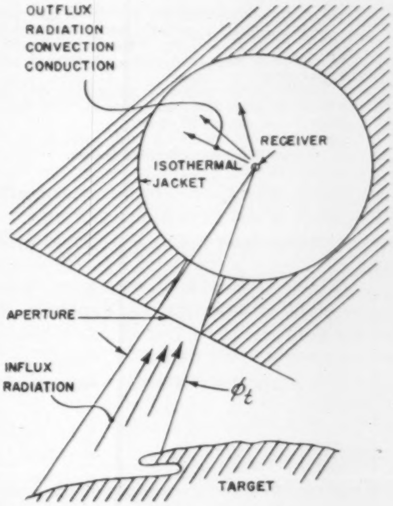


Fig. 5. Idealized Radiation Pyrometer.

THEORY OF THERMOELECTRIC RADIATION PYROMETRY

Fig. 5 shows an idealized radiation pyrometer—a small receiver of low heat capacity, a spherical jacket of high heat capacity and temperature T_j, and a transparent window through which a target of temperature T_t may be "seen" by the receiver through a solid angle of ϕ_t steradians. We may write the steady state energy flow equation governing the receiver temperature T_r:

$$K_0(T_t^4 - T_r^4) = K_1(T_r^4 - T_j^4) + K_2(T_r - T_j)^y + U_3(T_r - T_j) \quad . \; . \; . \quad (1)$$

or in words, the influx radiant energy to the receiver is equal to the net energy transfer from receiver to jacket by radiation, convection, and conduction.

We may introduce a gross approximation for the convection term without seriously jeopardizing our qualitative conclusions:

$$K_2(T_r - T_j)^y = U_2(T_r - T_j) \quad . \; . \; . \; . \quad (2)$$

If the difference between T_r and T_j is less than say 1%

NOTATION

T_t = Target absolute temperature.
T_j = Absolute temperature of pyrometer jacket.
T_r = Absolute temperature of pyrometer receiver.
K_0 = Constant governing radiation between target and receiver.
K_1, U_1 = Constants governing radiation between receiver and jacket.
K_2, U_2 = Constants governing convection between receiver and jacket.
U_3 = Constant governing conduction between receiver and jacket.
ϕ_t = Solid angle of radiant influx from target to pyrometer receiver.
y = Exponent of temperature difference applicable to convection between receiver and jacket.

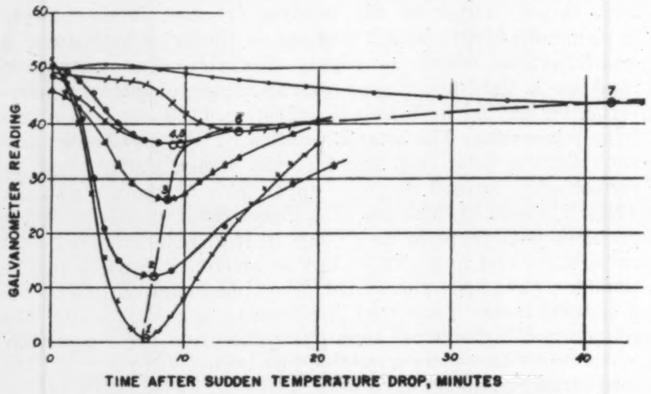


Fig. 6. Zero-drift in a commercial vacuum type pyrometer.
Solid lines: zero-drift vs. time curves produced by a sudden 30°F. drop in cooling water temperature with seven combinations of thermal resistance and capacitance confined in outer jackets of equal size.
Dashed line: trend of magnitude and duration of zero-drift with variation in jacket construction, indicated by the peaks (numbered points) of the solid lines.
Point numbers go up with increase in "heat-mass" concentration of the jacket arrangements tested.

of either, the receiver-to-jacket radiation term may be written with fair precision:

$$K_1(T_r^4 - T_j^4) = U_1 T_j^3 (T_r - T_j) \quad . \; . \; . \quad (3)$$

On the left side of equation (1), T_r may be replaced by T_j, since compared to T_t their difference is in general negligible.

We may now rewrite equation (1) to give a function which is more readily scanned by eye, if slightly less precise:

$$K_0 T_t^4 = (U_1 T_j^3 + U_2 + U_3)\,(T_r - T_j) + K_0 T_j^4 \quad . \quad (4)$$

Then, in order to measure T_t with precision, we must measure precisely a magnitude proportional to $(T_r - T_j)$ and we must know T_j itself at least approximately.

Many forms of radiation pyrometers have been built in which radiation from a hot target is intercepted by a receiver to produce a temperature difference between the receiver's "hot" junctions and "cold" junctions located vaguely somewhere else. It must here be recognized that the criterion temperature difference is that between the receiver and the jacket walls. Failure to locate the thermoelectric cold junctions at the walls leads to a time lag between the walls and the cold junctions when the slightest drift in jacket temperature occurs. This will produce the ZERO DRIFT previously referred to, which in low-temperature applications may frequently amount to *several hundred percent* of the criterion temperature difference $T_r - T_j$, and render the output of the pyrometer meaningless. This random location of cold junctions "somewhere else" may be largely responsible for the prevalent notion that radiation pyrometry is impractical at temperatures appreciably below 1400°F.

Let us therefore, locate in our ideal pyrometer a thermoelectric element with hot junction at the receiver and with cold junctions at the walls, and since we will require a knowledge of $T_r - T_j$ to within a few thousandths of a degree, let us use a massive high-conductivity jacket to assure that its temperature will be *uniform* throughout.

The term $K_0 T_j^4$, equation (4), will be found negligible for 0.1% accuracy in target temperature measurement, when $T_t > 4T_j$, while a 4% variation of T_j from that at which calibration was made will be negligible when $T_t \approx 2.5T_j$. Thus at normal room temperature, T_j may vary ±20°F. with no effect when T_t is above about 800°F., so far as the influx of radiant energy from the target is concerned.

A more troublesome effect of jacket temperature deviation lies in the variation of radiant energy transfer within the pyrometer, indicated by the factor $U_1 T_j^3$, equation (4). When we strive for high output by evacuating the pyrometer jacket and making the thermoelectric elements as slender as possible (decreasing U_2 and U_3) we make the effect of jacket temperature change more and more critical. By retaining a high convection rate at a sacrifice of output, and by polishing the inner jacket wall to reduce U_1 we may render the effects of small deviations of jacket temperature negligible.

The coefficient K_0, equation (4), is dependent upon the geometry of the arrangement and the "blackness" of the target surface. It may be increased by increasing the value of ϕ_t by the change of aperture size, usually entailing an undesirable increase in area of the target portion viewed, or by the use of a lens. A lens or window is never perfectly transparent, and contributes to the effective jacket temperature. A large lens external to the heavy jacket proper is, therefore, apt to present difficult temperature control problems, and is to be avoided. K_0 may be further increased by pre-treatment of the target surface as described under "Tests." Here repeatability of calibration is even more important than the increase in output.

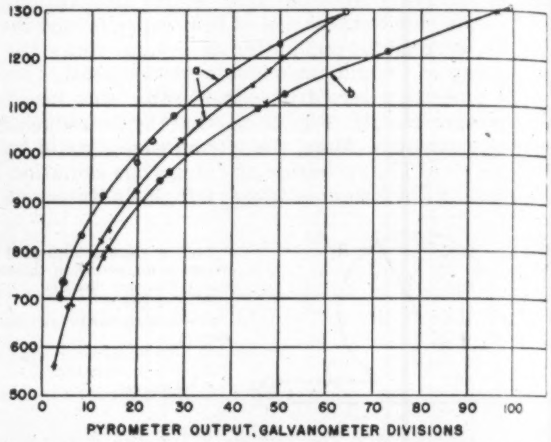


Fig. 7. Effects of target pre-treatment on thermoelectric radiation pyrometer.

a—Target polished before test.

b—Target lightly sand-blasted and preheated to 1400°F.

Encircled test points indicate increasing temperature.

Crossed test points indicate decreasing temperature.

Point scatter, curve b, is typical of pyrometer repeatability.

The radiation transmission within the pyrometer may be reduced for increased output by polishing the inner jacket wall surface. The conduction factor U_2 has been commonly reduced by using extremely thin thermocouple wires or ribbons.

The convection factor U_3 is a function of the shape, size, and pressure of the jacket interior. In general, evacuating a pyrometer will increase its output by a ratio of seven or ten to one. The transition of sensitivity occurs rather suddenly over a limited range of pressures, through which the mean free path of the molecules of gas in the jacket appears to be of comparable order to the linear dimensions of the inner jacket chamber. It must be remembered that the tempting increase in ouptut will demand much closer control and measurement of the pyrometer jacket temperature unless the radiation factor $U_1 T_j^3$ can be reduced proportionately.

A rigorous analysis of pyrometer performance will yield an equation quite different from equation (4), involving among other things an integration of a function of "monochromatic" radiation "density" in a differential spectral band at varying temperature with respect to the spectral distribution of a non-black surface, further modified by the selective transmission of the particular window or lens material—hardly a feasible project in wartime. It is sufficient to say that the result is not a fourth-power function, nor is the pyrometer in any sense a "total radiation" pyrometer. Empirical formulae involving a temperature exponent between four and five have been found to fit portions of the calibration curves, but they have contributed nothing to the usefulness of the project. Attempts to use equation (4) for any but qualitative considerations should be avoided.

TESTS

1. Tests of zero-drift in a commercial vacuum type pyrometer were conducted to determine the optimum arrangement of thermal resistance and capacitance between a water-cooled housing of fixed diameter and the pyrometer. No aperture or target was used. The criterion for zero-drift was the pyrometer output vs. time curve of each arrangement, produced by a sudden drop of 30°F. in water temperature. Fig. 6 shows the results obtained with seven such arrangements, which are numbered in order of increase of "heat-mass" concentration. The dashed line through the peaks of these curves shows the trend from high drift of short duration to low prolonged drift. Curve #7 was obtained with an arrangement similar to Fig. 2b, which in service permitted zero-drift adjustment, a target observation, and a good zero check after observation.

Zero-drift in the experimental pyrometer of Fig. 4 was determined by a sudden increase of 37°F. in the jacket temperature. The zero-drift persisted for about seven minutes, and its maximum value was about four galvanometer divisions at the end of three minutes. The effect of this zero-drift is shown in Fig. 9 (b). Since no such sudden jacket transients occurred in service, the use of a zero adjuster and cold reference target was discontinued, eliminating the reference target reflection error previously described.

2. Repeat calibrations at several jacket temperatures indicated the significance of jacket deviations in service. The commercial pyrometer required a correction of a little over one degree per degree deviation of jacket temperature at a target temperature of 1200°F., and an increase in the correction as the target temperature rose. The corresponding correction for the experimental pyrometer without vacuum was less than one-quarter degree per degree, with a tendency to *decrease* with an increase in target temperature. This tendency is not apparent from equation (4), and is best explained by the fact that the convection exponent y, equation (1), is appreciably greater than unity, so that the value of U_2, equation (4) increases with $(T_r - T_1)$. In words, the rate of heat transfer between the receiver and jacket by convection increases with target temperature faster than does the transfer by radiation. The effect upon the required correction is a real trouble-saver.

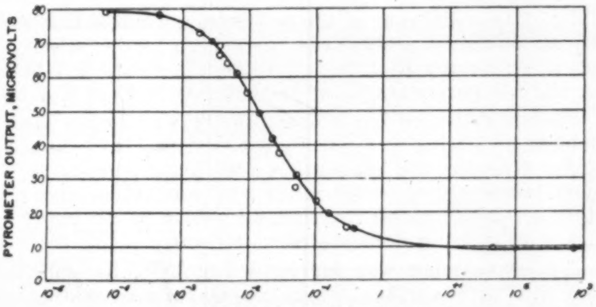


Fig. 8. Effects of internal pressure variation on thermoelectric radiation pyrometer output with constant target temperature.

3. Tests on the effects of target emittance drift were conducted by using a calibrating target of test-target material, initially bright, which was gradually heated and cooled. Readings of pyrometer output with increasing and decreasing target temperature were observed. Fig. 7 shows the results obtained with two initial surface conditions. It was found that a light sandblast of the calibrating target rendered the emissivity drift negligible (Fig. 7b) though in subsequent tests where turbine wheel temperatures were to be observed, both wheel and calibrating target were preheated to the highest contemplated test temperature (or as closely as possible without metallurgical damage) after a light surface sandblast.

4. The "calibration repeatability" tests were identical with the target emittance drift tests where no visible effect of emittance variation occurred, Fig. 7b. In addition, a series of closely-spaced calibration points were obtained and plotted on a highly expanded scale. The scatter of the test points about a smooth curve drawn through them is shown in Fig. 9, (a) and (c), where the greatest deviation noted is 3.5°F., or a spread of 7°F. It was expected that the point scatter would decrease at elevated target temperatures because of the decrease in slope of the calibration curve. In practice, it was found that at temperatures above 1000°F., target temperature vs. time curves taken with the radiation pyrometer were much smoother than those taken with the base-metal contact thermocouple peened into the target's surface. It is justifiable, therefore, to blame the persistent scatter at elevated temperatures on the poor adaptability of the contact thermocouple to precise measurement of surface temperatures when air or gases at different temperatures are present.

In early wheel tests, *vibration* produced occasional shift between pyrometer and jacket, changing the solid angle of sight. Another source of difficulty was *sooting* of the pyrometer aperture, which was eliminated by the use of an air jacket outside the water jacket. This also eliminated the *water film* formed occasionally by condensation on the aperture. Water is extremely opaque to infrared radiation. All of these possibilities must be carefully guarded against.

5. Tests on the effect of varying internal pyrometer pressure were conducted on the experimental pyrometer of Fig. 4, by sighting on an electric lamp of controlled voltage and connecting the evacuating tube to a good vacuum pump. Fig. 8 shows the result and is comparable to the characteristic curve of a thermocouple type vacuum gage. Note that rough evacuation produces no appreciable change in sensitivity and that there is a point (presumably where conduction and radiation transfer swamp out the remaining convection transfer) where further refinement of the vacuum is useless. It is interesting to note that the inflection point of the curve of Fig. 8 occurs at a pressure corresponding to a mean-free-path for air molecules of approximately 0.1", while the actual distance from receiver to inner jacket wall was about ⅛".

To date, the device of Fig. 4 has presented sealing difficulties and has been applied in turbine wheel temperature measurement at atmospheric pressure in mountings similar to that shown in Fig. 2, with considerable reduction of bulk. The resulting reduced sensitivity has been offset at low temperatures by the use of certain crystalline salt apertures, transparent to infrared, in place of glass. The relative freedom of this arrangement from the effects of small jacket temperature deviation has reduced personal supervision of tests to a minimum.

CONCLUSIONS

The requirements for basically sound thermoelectric radiation pyrometry may be briefly stated:

1. The target surface must be of constant "blackness" throughout calibration and application.

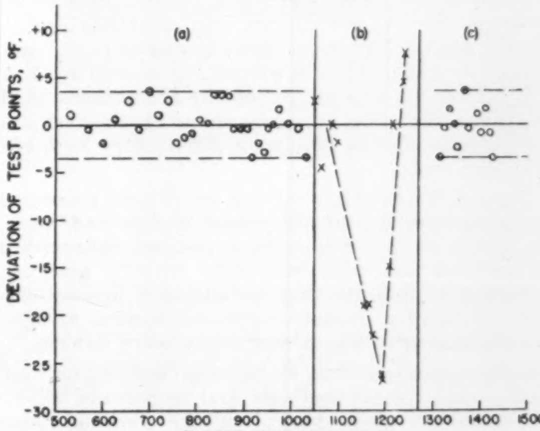


Fig. 9. Performance of miniature radiation pyrometer calibrated at atmospheric pressure.

a, c—Point scatter about a smooth curve. Pyrometer jacket held at 66 ±2°F.

b—Zero-drift introduced by a sudden increase of 37°F. in jacket temperature.

2. It is necessary to make a precise measurement of the difference in temperature *between a receiver and its surrounding jacket,* or the corresponding emf, or galvanometer equivalent.

3. It is necessary to measure or know at least approximately, and in applications below about 800°F. precisely, the temperature of the jacket.

4. It is advantageous to sacrifice the high output associated with an evacuated pyrometer when freedom from the effects of small jacket temperature variations is essential.

5. There must be interposed between the pyrometer cold junctions and a cooled outer jacket a high heat-capacity, high conductivity jacket, surrounded by at least a thin layer of good thermal insulation.

Thermoelectric radiation pyrometers are normally free of the deteriorating influences to which high-temperature contact pyrometers of even the noble-metal thermocouple type are subject. A little regard for the thermodynamics governing their performance has lowered the minimum practical application temperature from 1500°F. (4) to about 300°F., and there is no reason to state a minimum for further development. The field of application has been broadened from industrial furnace applications requiring about a square inch of "target" area, to include local surface measurement with target diameters of a quarter inch or less, with repeatability equal to or better than that of the contact thermocouple. Procedures for improved hot-gas temperature measurement utilizing the thermoelectric radiation pyrometer are in sight. The integration of the laws of monochromatic radiation over the broad spectral band of a suitable window or lens material to create a reproducible high-temperature standard of long life is not beyond the realm of post-war probability.

ACKNOWLEDGMENTS

The pioneering in this project was made possible by the efforts and enthusiasm of Messrs. S. S. Stack, W. S. Thompson, N. F. Frischhertz, and R. H. Norris.

The author is also indebted for the valuable assistance of many other employees of the General Electric Company, and acknowledges particularly the efforts and suggestions of Dr. C. W. Hewlett, Messrs. S. I. Pearson, R. D. Ellis, F. O. MacFee, W. J. King, M. C. Hemsworth, W. MacRobbie, Jr., and G. W. Crosby toward the design, construction, and test of the experimental equipment described.

BIBLIOGRAPHY

(1) "Vacuum Thermocouples of the Radiation Type." S. S. Stack, *General Electric Review,* Vol. 42, No. 8, August, 1939, pages 365 to 366.

(2) "Measurement of High Temperatures in High-velocity Gas Steams," W. J. King, *Transactions ASME,* Vol. 65, No. 5, July, 1943, pages 421-430.

(3) "The Measurement of Flame Temperature," G. Ribaud, Y. Lauri, H. Gaudry. *Journal of the Institute of Fuel,* Vol. XII, No. 64, March, 1939, pages S-18 to S-30.

(4) ASME Power Test Codes: "Instruments and Apparatus": Part 3, "Temperature Measurement," Chapter 2, "Radiation pyrometers."

High-velocity Air Stream Temperature Measurements

By H. C. HOTTEL, Massachusetts Institute of Technology, Cambridge, Mass.
and A. KALATINSKY, Pratt & Whitney Aircraft, East Hartford, Conn.

If a gas is stagnant, its thermodynamic state is determined by its pressure and temperature. If the gas is in motion, two ideal states may be defined: the "true" state which would be observed by instruments moving together with the gas; and a "stagnation" state which the gas assumes when it is brought to a complete stop and its kinetic energy is converted, without loss, into a temperature rise. A stationary instrument inserted into a gas stream may indicate a temperature or pressure corresponding to any condition lying between the "true" and the "stagnation" states and even, under certain conditions, a temperature in excess of the "stagnation" temperature.

The pressure and temperature differences between these two states may amount to as much as 13 lbs./in.^{2} and 130°F. for supercharger operation, and up to 400°F. for exhaust gases. Hence the importance of reliable data on the recovery characteristics of the measuring devices.

Accurate measurements of the true (static) and of the stagnation (total) pressure can be obtained simultaneously from a Pitot-static tube.

On temperature measurements, only relatively few data—conflicting and inconclusive—were available in the summer of 1940. For this reason a project, sponsored by Pratt & Whitney Aircraft, was carried out by the authors at M.I.T. to determine the effect of probe shape on the temperature recovery factor and to develop a satisfactory high-velocity temperature probe.

A number of investigators had previously measured the recovery factors of commonly-used probes and of simple bodies. Attempts to correlate these results either with probe shape or with test conditions were entirely unsuccessful. This seemed to indicate that no adequate precautions had been taken against radiation and conduction errors. The temperature measurements themselves were dubious.

It became apparent that any new investigations would be of value only if test methods and apparatus were used which permitted close control of the various causes of errors. The authors believe that the test set-up used in this investigation largely fulfilled this condition.

Fig. 1 is a diagram of the test set-up. The calibration of the high-velocity probes was carried up to the velocity of sound by moving the test set-up to the Pratt & Whitney Aircraft Experimental Test Department in East Hartford.

The air delivered by the compressor was cooled back to ambient by letting water flow over the outside of the surge tanks. Keeping the stagnation temperature equal to the room temperature, which minimized conduction and radiation errors all along the line, proved to be an important factor in insuring accurate measurements.

The jet chamber was surrounded by a cylindrical shield provided with surface thermocouples and a heating coil wound on the outside and insulated to insure a uniform temperature distribution. The heating coil was used for determining the radiation sensitivity of various probes, but for straight recovery measurements it was found more reliable to keep the probe temperature equal to the room tem-

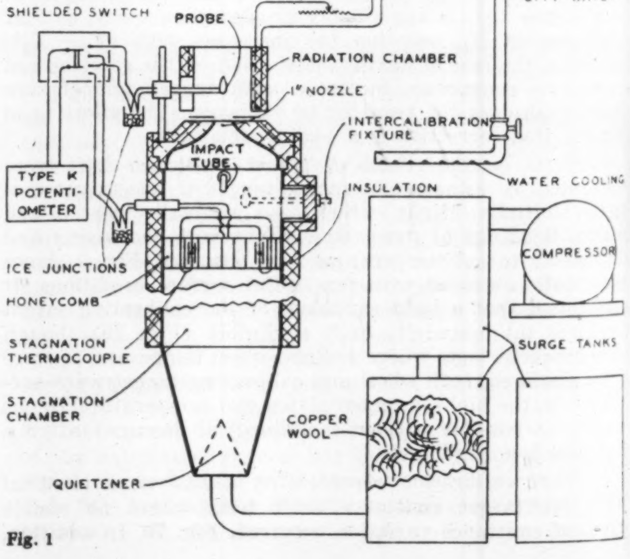
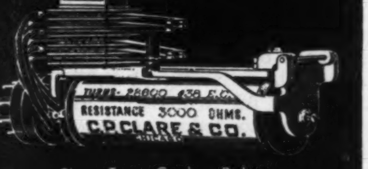


Fig. 1

EXTENDED ABSTRACT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Aviation and Heat Transfer Divisions.

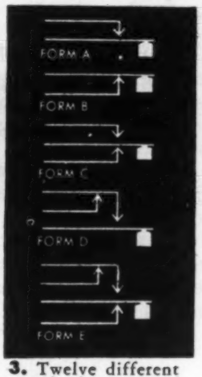
This CLARE Relay Can Take the Place of Many

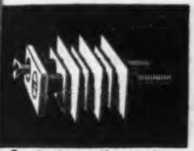

RESISTANCE 3000 OHMS.
C.P. CLARE & CO.

Clare Type C d. c. Relay

This rugged multiple-contact relay permits innumerable contact arrangements. Permits designing to small size, with a lesser number of relays; and facilitates maintenance. Adapted for use in electronic control devices and for sequence control and interlocking operations. Ideal where unusual arrangements of relay control are desired. Here are the reasons why:

1. Contact springs employing any of the forms illustrated can be furnished.



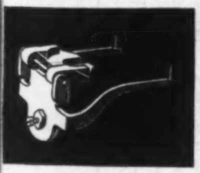


2. Spring pile-up insulators of heat treated Bakelite which permit punching without cracks, have minimum cold flow and low moisture absorption content. Assembly locked together under hydraulic pressure. Withstands heavy breakdown tests.

3. Twelve different standard or special types and sizes of contacts can be furnished. Contacts are overall-welded to nickel silver springs. Sizes range from .062" silver, rated one ampere, 50 watts, to .1875" tungsten, rated four amperes, 500 watts.

4. Spring bushing insulators are Bakelite rod made by a patent process. Strong, hard, long wearing. Essential where heavy contact pressures are employed, where vibration exists, or heavy duty service is desired.

5. Armature assembly single or double arm. Has stainless steel shaft, operating in a marine brass yoke. Heel piece, coil core and armature are magnetic metal carefully annealed. Designed for d.c. service.



6. As illustrated, relay has octal base plug mounting for easy service and replacement. Other mountings, and Bakelite or metal cover, can be supplied.

• • •

This relay is an example of Clare "custom-built" design and construction. Clare engineers can "custom build" a relay to meet your specific requirements—one that will reduce your overall relay cost and simplify your design problem. Write for catalog and data book. C. P. Clare and Co., 4719 West Sunnyside Avenue, Chicago.

CLARE RELAYS

"CUSTOM-BUILT" Multiple Contact Relays for Electrical, Electronic and Industrial Use

SHIP WHEN READY-

the secret of getting FASTEST DELIVERY

Don't wait for "routine" afternoon pickups, when shipping AIR EXPRESS. Get your shipments on the way as soon as they are ready—as early in the day as possible.

That's the secret of getting fastest delivery. Because you avoid possible delay, due to end-of-day congestion when Airline traffic is at its peak.

And to cut costs—AIR EXPRESS shipments should be *packed compactly* but securely, to obtain the best ratio of size to weight.

A Money-Saving, High-Speed Tool For Every Business

As a result of increased efficiency developed to meet wartime demands, rates have recently been reduced. Shippers nationwide are now saving an average of more than 10% on Air Express charges. And Air Express schedules are based on "hours", not days and weeks—with 3-mile-a-minute service direct to hundreds of U.S. cities and scores of foreign countries.

WRITE TODAY for "Vision Unlimited"—an informative booklet that will stimulate the thinking of every executive. Dept. PR-1, Railway Express Agency, 230 Park Avenue, New York 17, N. Y.

AIR EXPRESS

Gets there FIRST

Phone RAILWAY EXPRESS AGENCY, AIR EXPRESS DIVISION
Representing the AIRLINES of the United States

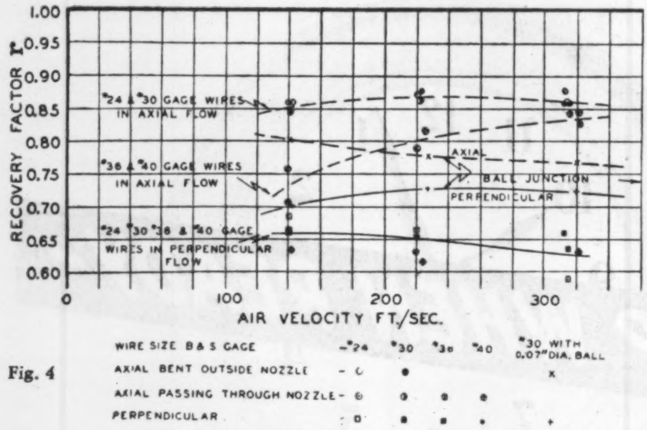


Fig. 4

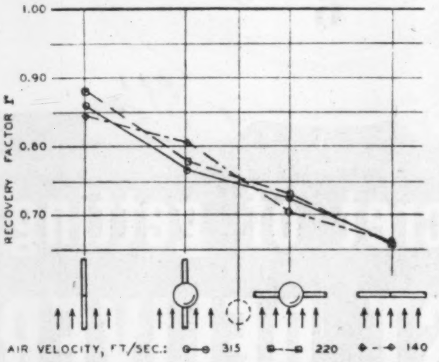
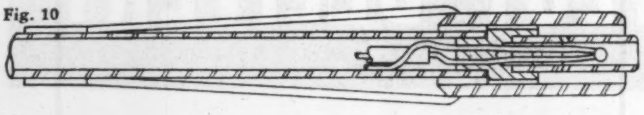


Fig. 6

Fig. 10



perature by regulating the amount of intercooling after the compressor, since the shield covered only 59% of the field of vision of the probe.

In selecting a method of temperature measurement in high velocity streams, the choice has to be made between probes designed to record the true temperature, probes to record the stagnation temperature, and conventional probes accurately calibrated for recovery factor.

Since any stationary probe slows down the gas in its immediate vicinity, measurement of true temperatures with ordinary probes is not possible.

Stagnation temperature measurements have the advantage of yielding more representative data with respect to energy conditions and, in many cases, with respect to heat transfer than intermediary readings obtained with a calibrated conventional probe. The principal advantage of a stagnation probe lies, however, in the considerably improved reproducibility of calibration results.

For measurements which do not justify the use of special stagnation probes, the recovery characteristics of commonly-used bare wire thermocouples were investigated. The reproducibility of the test points was found to be generally better than ±5% of recovery. This may be considered entirely adequate for temperature measurements in the low-velocity range (below 300 ft./sec.) which do not have direct efficiency determination for their object.

Radiation errors may be caused by differences, usually present, between the stagnation temperature and the temperature of the walls of the duct into which the probe is inserted. The authors derive an equation for the radiation error of a probe with an enclosed stagnation chamber. They report finding that a good correlation of the test points was achieved by using a simplified equation.

The radiation sensitivity values reported should be adequate for the full range of supercharger temperatures.

Butt-welded iron-constantan thermocouples were made up from No. 24, 30, 36 and 40 gage wires. Practically perfect cylindrical welds were obtained by using mercury arc welding technique. A ball-junction couple was made up by melting a 0.07" solder ball around the butt-welded junction of a 30 gage couple. Twisted wire couples were made by twisting 30 gage insulated iron and constantan wires over a length of ½" and welding the ends (weld ball diam. = 2 wire diam.). It is important that the insulation of the twisted part of the wire remain undamaged up to the very top. This was achieved by using mercury arc welding.

All these couples were tested in both an axial and a perpendicular position relative to the flow. Fig. 4 shows the recovery factor plotted against air velocity for the butt-welded and ball junctions.

The considerable influence of the junction shape on the recovery factor is illustrated by Fig. 6, where all the test data for 30 gage wires, with and without the solder ball junction, are plotted against an arbitrary parameter of shape. One might be tempted to deduce a recovery factor of 0.75 for a perfect sphere by interpolating these data.

The Franz probe and the M.I.T. probe are illustrated and reported in detail. The M.I.T. probe was designed to obtain better orientation characteristics and to eliminate the instability of the diffusor. It was made adaptable to small-scale construction (Fig. 10). Body and support were made from stainless steel hypodermic needle tubing. The thermocouple itself was made from 40 gage iron and constantan wires with spun glass insulation. Recovery factors are higher than for the Franz probe; scattering of calibration points relatively small; orientation characteristics good.

The Pratt & Whitney Probe.—After the conclusion of the project at M.I.T., further development of stagnations probes was carried on at Pratt & Whitney Aircraft by Mr. F. Clark under the direction of Mr. J. H. Marchant. The M.I.T. probe, as originally designed, was difficult to manufacture and was not rugged enough for supercharger testing. These shortcomings have largely been overcome in the Pratt & Whitney probe, Fig. 12. Its radiation sensitivity is the same as that of the original M.I.T. design.

The Pratt & Whitney high-velocity stagnation temperature probe is satisfactory for precision measurements. It has good recovery characteristics, is insensitive to angles of yaw under 12° and is not subject to serious radiation errors. Bare wire thermocouples can be used for the great majority of measurements at velocities below 300 ft./sec.; sufficiently accurate information on their recovery factors is now available.

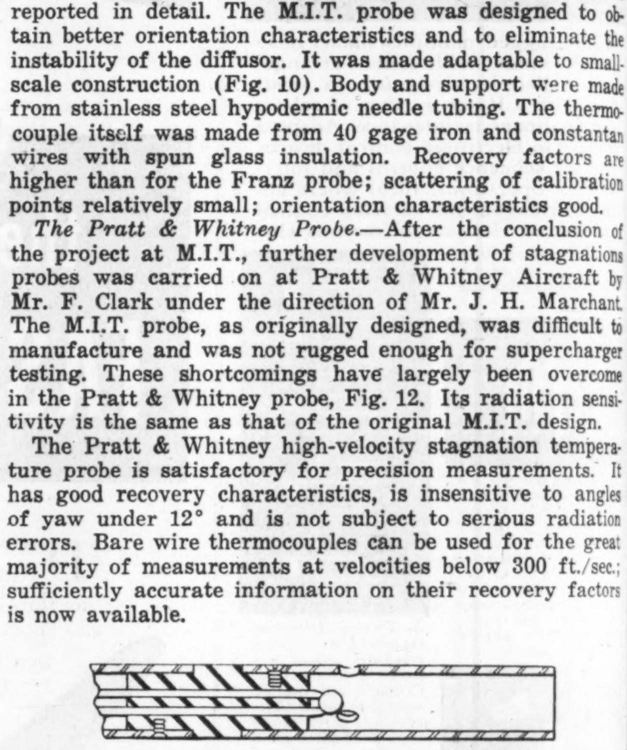


Fig. 12

Post War
Clock Movements
by
CHELSEA

Our production of special clock movements and clockwork mechanisms for recording instruments must wait until this war is won. Meanwhile, we would welcome the opportunity of working with you in developing your post-war designs.

Remember, Chelsea has been making special movements for recording instruments for many years.

Let's continue to back the attack!

**CHELSEA
CLOCK COMPANY**
385 EVERETT AVENUE
CHELSEA 50, MASS.

HOW FAR CAN YOU SEE?

1944
1945
1946
1947

With every forward step in the science and arts of optics, man's vision leaps ahead by light years into the universe . . . advances steadily towards the apprehension of the atom.

Specialists in the application of the optical sciences to some very practical arts, Kollmorgen pioneered the periscope . . . and for years has been one of the principal manufacturers of periscopes, navigation and fire control instruments for the U. S. Navy.

A quarter century of research and experience in the solution of problems in mechanics as well as optics . . . and a large force of technicians trained in fine craftsmanship and close tolerances in glass and metals . . . are available for the peacetime needs of industry, science and education.

If you can see ahead now . . . advise us of your coming plans and problems.

KOLLMORGEN OPTICAL CORP.
2 Franklin Avenue Brooklyn 11, N. Y.

"SURCO-AMERICAN"
means PRETESTED
under all conditions

"Surco-American" high quality flexible plastic tubings and insulated wire are pretested to stand up under a wide range of temperatures and under the most severe conditions because they are specially formulated to meet the most exacting requirements. Tubings are available in inside diameters from .005" to 2". Dielectric strength averages 1500 volts per mil. thickness . . . "Surco-American" flexible plastic insulated wire is available in all lengths and colors in wire sizes #12 to #48 A.W.G. solid or stranded, shielded, tinned or silver plated copper wire and cable . . . Technical bulletins and samples on request.

Address Dept. I

Surprenant
ELECTRICAL INSULATION CO.
84 Purchase St. Boston, Mass.

PERMANENT
MAGNETS

The Arnold Engineering Company produces all **ALNICO** types including **ALNICO V.** All magnets are completely manufactured in our own plant under close metallurgical, mechanical and magnetic control.

Engineering assistance by consultation or correspondence is freely offered in solution of your magnetic design problems. All inquiries will receive prompt attention.

THE ARNOLD ENGINEERING COMPANY
147 EAST ONTARIO ST. • CHICAGO, ILLINOIS

From 130° Above
to 60° Below Zero

Wartime use of aircraft, in the deserts of Africa, in the frozen far North . . . flying from scorching earth to sub-zero temperatures of extremely high altitudes in a few minutes' time . . . these conditions have created a definite need for dependable, automatic temperature control devices . . . in these wartime planes, in jeeps, trucks and other fighting equipment Chace actuating elements are providing constant and reliable control of important temperature responsive devices.

Of course Chace Thermostatic Bimetal actuating elements for automatic temperature control are incorporated in essential civilian products too.

And for postwar activities, remember Chace utilizes 25 different alloys to produce 35 different types of thermostatic bimetals. May we suggest the type most suitable for the actuating element of your temperature responsive devices?

W.M. CHACE CO.
Manufacturers of
Thermostatic Bimetals and Special Alloys
1609 BEARD AVE • DETROIT 9, MICH.

Application of Electronic Control

EXTENDED ABSTRACT of paper presented at Annual Mee ing of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices Design and Materials Handling Divisions.

By E. H. VEDDER, Manager, Electronic Control Sectio
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

ELECTRONIC control has been developed which will d many things better, less expensively, faster or mor precisely, as well as many things previously impossible, bu careful attention must be given to coördination of mechanical and electronic functions. Electronics is not a gadge business but a tool which must be properly used within it limitations. Examples of the more important development are given. An electronic control has now been develope which operates a d-c. motor from an a-c. line. An electroni adjustable-speed drive described consists of a d-c. shun wound motor whose field and armature are energized b separate thyratron-rectifier circuits. These rectifiers are s controlled as to vary the input to the motor, regulate th motor speed to a pre-set value, and limit the maxim current furnished the motor during acceleration and reversal.

Resistance welding is divided into distinct classes suc as spot, projection, butt, and seam welding. Spot, projection, and butt welding differ only in the type of electrode and method of holding the materials during welding an use the same control unit. The control measures out one o more pulses of current to make an individual weld. Sea welding uses roller electrodes and the control (quite different from that for spot welding) causes the current to flo in individual pulses of a few cycles' duration each and wi a few cycles' time between each pulse for as long as welding is proceeding.

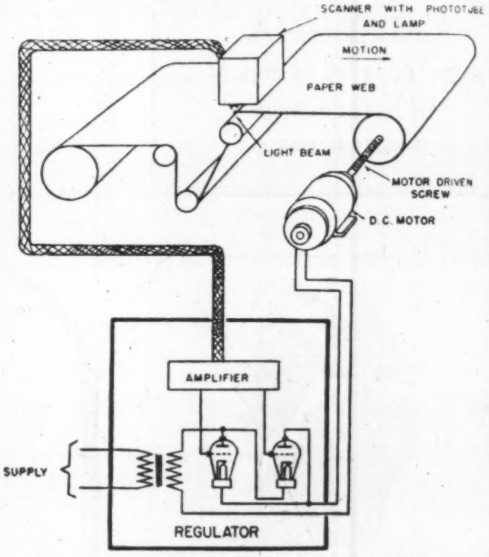
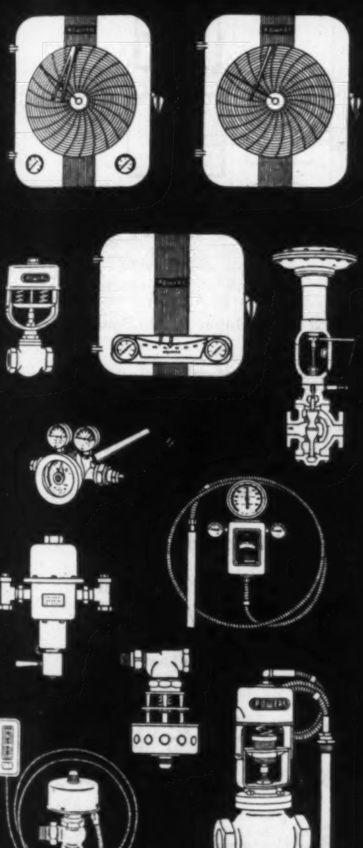


Fig. 8. Schematic Arrangement of Regulator for Controlling Slitting or Rewinding of Paper, Glassine, or Cellophane.

Photoelectric control, in which the control is actuated b the response of a phototube, is useful for actuating a system in response to a change of color, shade, density, shap or position without mechanically touching the controllin object. As an example when slitting strip material, it ofte is necessary to regulate the sideways position of the we to insure cutting at the proper point relative to a trad mark or printed design. The slitter regulator shown i Fig. 8 scans the edge of the paper web or a line in th printed design. The proper web position is obtained b moving the roll of material to the position called for b the phototube in the scanning device. The same device i used to scan the edge of a web and correct the roll positio to insure smooth roll wind-up when rewinding mill rolls.

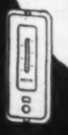
Wartime shortage of tin brought about the necessity f

POWERS
TEMPERATURE and HUMIDITY
CONTROL



When you want accurate and dependable automatic temperature or humidity control for Industrial Processes, Heating or Air Conditioning Systems, call in a Powers engineer. With over 50 years of experience and a very complete line of self-operating and air operated controls we are well equipped to fill your requirements.

Write for Circular 2520
2734 Greenview Ave., Chicago
Offices in 47 Cities—See your phone directory.



THE
POWERS REGULATOR CO.

Protect Irreplaceable Equipment by NEW FUSING

I DON'T KNOW!
HOW SOON CAN WE GET ...?

Electrical installations for:
X-Ray Inspection Testing Plant Communications Fire and Burglar Alarms Meters
THOUSANDS OF OTHER UNITS

FUSE EVERY INSTRUMENT FOR SAFETY WITH

Littelfuses

Many of these instruments are *irreplaceable*. Present equipment must be kept on the job!

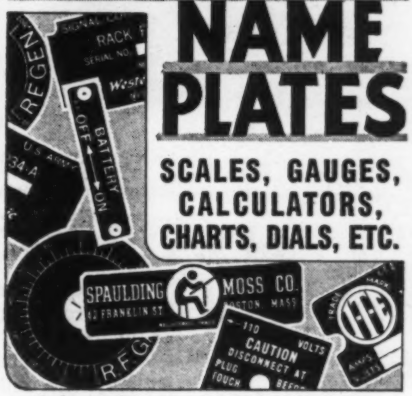
EFFICIENT FUSING is vital protection from damage. Many plant operators are installing NEW fusing throughout.

Littelfuse will be glad to help you with practicable suggestions. Feel free to call on us.

Instrument Littlefuse

LITTELFUSE Inc.
263 Ong St., El Monte, California
4793 Ravenswood Ave., Chicago 40, Ill.

PLASTIC NAME PLATES



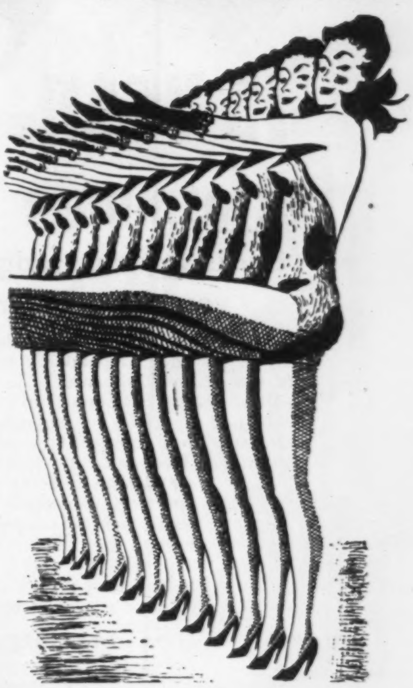
SCALES, GAUGES, CALCULATORS, CHARTS, DIALS, ETC.

- Impervious to moisture, grease, oils, acids, alkalis.
- Printing guaranteed not to wash or rub off.
- Non-inflammable, non-corrosive plastic.
- Printed and laminated vinylite and cellulose acetate.

SAMPLES AND ESTIMATES GLADLY SUPPLIED ON REQUEST
WRITE DEPARTMENT M. I.

THE HOPP PRESS, INC.
PRINTING—FABRICATING—FORMING
460 W. 34th STREET, N. Y. C.
ESTABLISHED 1893

UNFAILING PRECISION



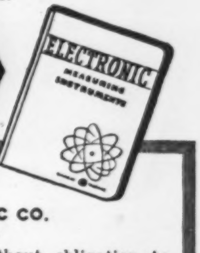
In the new General Electric line of ELECTRONIC MEASURING INSTRUMENTS, unfailing precision is just one of many invaluable features designed by the famous G-E electronics laboratories—you are given a wide choice of accurate apparatus for service, maintenance and research work.

The units include: G-E unimeters, capacitometers, audio oscillators, wide band oscilloscopes, square wave generators, signal generators, power supply units and other utility measuring instruments.

These units are now in production primarily for the Armed Forces . . . but they may be purchased on a priority if you are in war work. After victory, the complete line will be available to all.

• *We invite your inquiry for G-E electronic measuring equipment made to meet your specific requirements.*

FREE CATALOG



ELECTRONICS DEPARTMENT
GENERAL ELECTRIC CO.
Schenectady, N. Y.

Please send, without obligation to me, the General Electric Testing Instrument Catalog, I-1 (loose-leaf), for my information and files.

*Name*________________
*Company*________________
*Address*________________

GENERAL ELECTRIC
177-C1
Electronic Measuring Instruments

Actual Size
—1/100 H.P.

15 YEAR

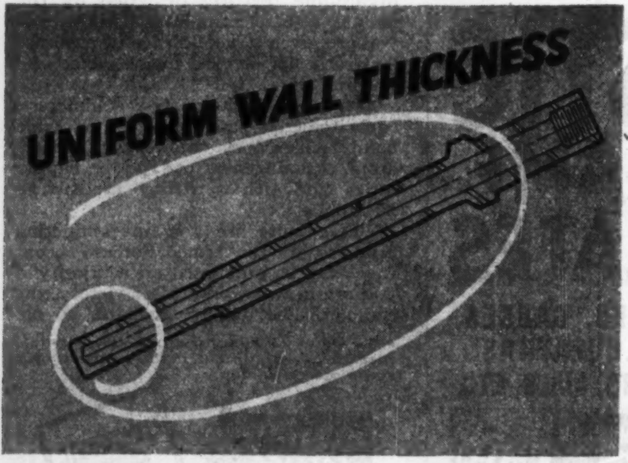
Performance Record

. . . backs up your judgment when you select Oster Motors

This record is your assurance that you are dealing with a seasoned, dependable source — that you are not "taking a chance.". . . Illustrated is type C-2B-1A, 1/100 H.P. model in current production; developed especially for aircraft use. Well adaptable to blower applications, under most adverse conditions. Designed for continuous duty to operate in high ambient temperatures (will operate satisfactorily in a 90° ambient). Ball-bearing-equipped. Built in an aluminum die-cast housing. 6, 12, 24, or 115 volts DC; 115 volts AC. Let us help you fit this or other Oster motors to your requirements. M-11B

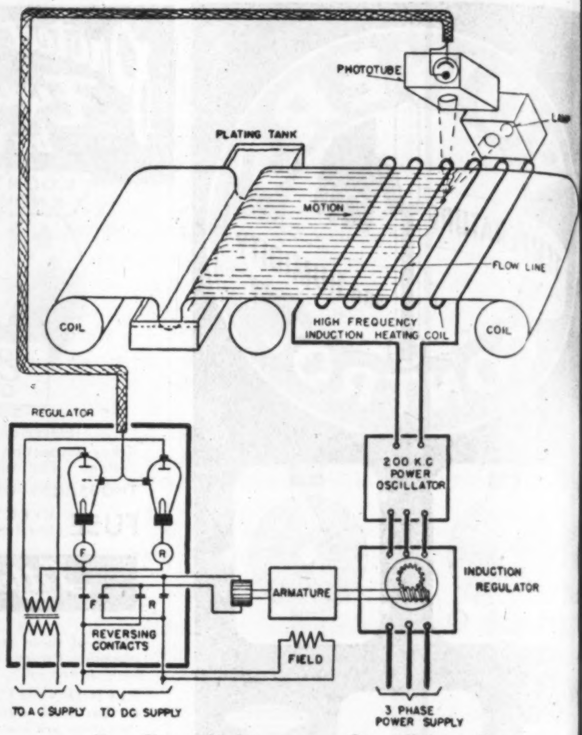
Oster
FRACTIONAL H.P. ELECTRIC MOTORS

John Oster Mfg. Co. of Illinois
Department N-11 **Genoa, Illinois**



Accuracy where it counts is maintained in all Trinity Thermocouple Wells. We are proud to be able to guarantee concentricity of bore in solid drilled wells up to 40″ long.

TRINITY EQUIPMENT AND SUPPLY COMPANY
136 Liberty Street New York, N. Y.



F Forward relay
R Reverse relay
—O— Relay coil
⊣⊢ Relay contact

Fig. 10. System for Regulating Power Input in Tin-flowing Process.

thinner coating of tin on strip steel for cans. This has been accomplished by the electrolytic tinning process. The electroplating process leaves the tin surface with a silvery appearance and somewhat porous structure. It is necessary to heat the strip enough to melt and flow the tin, and thus obtain a more perfect coating. The control system shown in Fig. 10 controls the amount of high-frequency power used to heat the surface to produce flowing of the tin coating.

A pin-hole detector for inspecting strip steel will inspect steel strip at speeds up to 1500 fpm. and detect 1/64″ or smaller holes, marking the holes as they occur.

The Theory and Design of Electronic-control Apparatus

EXTENDED ABSTRACT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices o Design and Materials Handling Divisions.

By W. D. COCKRELL, Electronics Application Engineer, General Electric Co., Schenectady, N. Y.

THE author reviews the fundamental conceptions of the electronic tube, describing the types of tubes used and the operation of individual control circuits. Examples o *standard electronic-control circuits* are given in detail, particularly the following: A photoelectric relay for miscellaneous work such as counting people or autos, package and cabbages, and cartons freshly painted, is composed o a simple rectifier, a capacitor and a series of resistors a the output end, a phototube and amplifier for conversion o light to electric current. A few refinements can be adde such as a rheostat for controlling the operational curren a small capacitor between grid and plate of the amplifie tube to prevent operation on slight light flickers and another capacitor between the d-c. potential and ground t prevent action due to slight changes in the a-c. powe supply. An electric timer can be built up by combining th capacitor-resistor fundamental timing circuit with a amplifier and a contactor operated by the amplifier.

A motor control (see diagram) which will regulate th speed of the motor quite accurately may be made by a pa

PERMANENT MAGNETS

BETTER . . . than Electro-Magnets for

MANY . . . Units

Meeting the Rigid Requirements of Sperry-Made Products

When lives and equipment depend upon precision instruments, "satisfactory performance" is not good enough for The Sperry Gyroscope Company. Perfection is demanded . . . and, in Cinaudagraph Permanent Magnets, perfection is obtained. We are meeting every rigid specification and a heavy production schedule—the reason, perhaps, why we are one of the larger suppliers of permanent magnets for Sperry.

Our extensive experience and manufacturing facilities can also help you solve your magnet problem.

ARMY E NAVY

I-CC-3

CINAUDAGRAPH
CORPORATION

STAMFORD, CONNECTICUT

Interval Timers

Process Timers

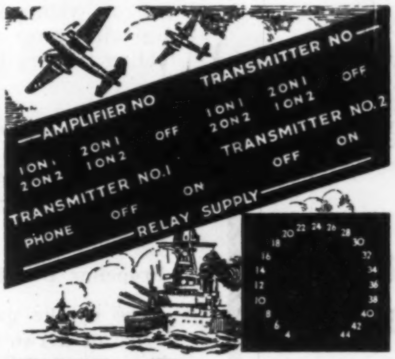
Signal Timers

Time Switches

Relays

Write

AUTOMATIC
ELECTRIC
MANUFACTURING CO.
MANKATO, MINNESOTA


AMPLIFIER NO
TRANSMITTER NO
1ON1 2ON1 OFF
2ON2 1ON2
1ON1 2ON1 OFF
2ON2 1ON2
TRANSMITTER NO.1
TRANSMITTER NO.2
PHONE OFF ON
OFF ON
RELAY SUPPLY
18 20 22 24 26 28 30 32 34 36 38 40 42 44 16 14 12 10 8 6 4

Silk Screens for WAR work!

A *proved,* ECONOMICAL method, in use by various war industries for reproducing DIALS, GAUGE, PANEL and INSTRUMENT markings, lettering, graduations, designs.

NO MACHINERY REQUIRED. Highly satisfactory for quantities from 10 to 10,000 impressions.

Send us copy, drawing or blueprint for estimate on complete screen and full details.

Silk Screen Supplies, Inc.
33 LAFAYETTE AVE.
BROOKLYN, N. Y.

LABORATORY STANDARDS

Standard Signal Generators
Vacuum Tube Voltmeters

Square Wave Generators
U.H.F. Noisemeters

Pulse Generators
Moisture Meters

MEASUREMENTS CORPORATION
Boonton, New Jersey

Gothard

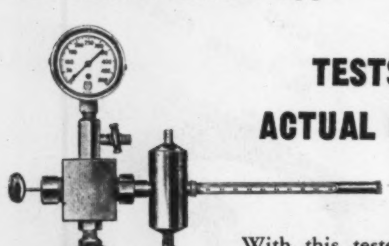
SERIES
1 0 0 0
110 VOLT
PILOT
LIGHT

for Mazda S-6 or T4¼—¼ Watt candelabria base lamp

Underwriters listed and approved. Gothard series 1000 Pilot Lights are totally enclosed, yet well ventilated for cool operation. Requires single 1" dia. hole for mounting. Standardly furnished for panels up to ⅜" thick—special requirements can be supplied. Jewel slips out of front for convenient replacement of bulbs. Faceted, smooth or frosted Jewels. Range of lens colors.

Request Gothard Pilot Light Assemblies catalog for complete information.

Gothard
MANUFACTURING COMPANY
1355 NORTH NINTH STREET, SPRINGFIELD, ILLINOIS



DEW POINT
TESTER
Bureau of Mines Type

SERVICE THE ACCURACY
R.S.Co.
TULSA
TRADE MARK REG.

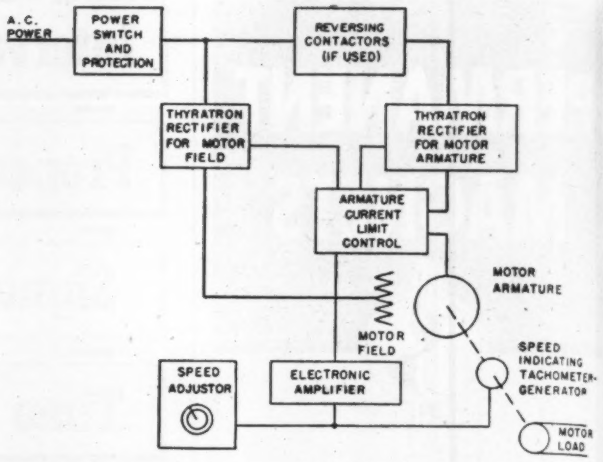
TESTS UNDER
ACTUAL CONDITIONS

With this tester it is possible to determine the dew point of gases under the conditions of pressure as they exist. Through the combined use of a refrigerant and a special stainless steel mirror dew points of gases are determined with an accuracy of 0.2° F. Suitable for working pressures up to 2500 P.S.I. and dew point temperatures as low as -90° F.

Catalog No. 26

SCIENTIFIC LABORATORY AND POWER PLANT EQUIPMENT

THE REFINERY SUPPLY CO.
Main Office and Plant
621 E. 4th Street TULSA, OKLAHOMA Ph. 4-8144, L.D. 581
Branch Office
1309 Capitol Ave. . . . . . Houston, Texas . . . . . Ph. Fairfax 5814


A.C. POWER
POWER SWITCH AND PROTECTION
REVERSING CONTACTORS (IF USED)
THYRATRON RECTIFIER FOR MOTOR FIELD
THYRATRON RECTIFIER FOR MOTOR ARMATURE
ARMATURE CURRENT LIMIT CONTROL
MOTOR ARMATURE
MOTOR FIELD
SPEED INDICATING TACHOMETER-GENERATOR
SPEED ADJUSTOR
ELECTRONIC AMPLIFIER
MOTOR LOAD

of rectifiers, one or both of which may be controllable, to supply the motor armature and field of a d-c. motor. An indication of the motor speed can be obtained either by connecting a tachometer-generator to it which will produce a voltage proportional to speed, or take the back-induced voltage from the motor. This is compared to a reference voltage, and the difference is amplified and applied to the control of the armature or field to hold the motor speed constant. If desired, other circuits can be added which operate from the motor current to limit this current to a safe value for motor and tube in spite of the demand for speed. A control can also be added to compensate for the resistance of the motor armature to obtain a flat compounding which is superior to that which can be obtained from a direct-compound motor.

In resistance welding close control of the timing and the intensity of the heat applied is necessary. These can be accurately controlled by proper devices.

Combinations of mechanical and electrical circuits are generally used on such devices as photoelectric register controls where, for example, it is desired to register printing with some mechanical operation such as cutting or folding the printed paper.

The Dyadic Gage

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By S. B. WILLIAMS

Propeller Division, Curtiss-Wright Corp., Caldwell, N. J.

The dyadic gage, as its name implies, is a measuring device of a two-fold nature, dyadic here being used in its simpler sense. The term refers not to a specific gage, but to a class of strain gages so arranged as to measure strains as a sum or difference of strains. Sometimes this is accomplished in a single unit or again by means of connecting two or more units together. However, all the component strains are limited to those coexistent at a point in a plane stress distribution. In order to demonstrate the complex result of the general case of two strain gages connected to add or subtract, the graphics of Mohr and dyadic circles are reviewed briefly and the relation between the two stress circles and the two strain circles is indicated by plotting all on the same co-ordinates. In developing a method of examining the properties of the dyadic gage, the graphics of solving the strain rosette are refined so that the complete stress picture may be obtained without computation. The superposition of the circles of strain and stress also provides a correlation between the state of strain and stress not heretofore emphasized. Thus it is possible to visualize the ratio of stress to strain as a function of direction.

It has been known for some time that most strain gages, and particularly the carbon units, have yielded erratic results when arranged to measure the Poisson strain in an axial distribution. The author has shown that the output

CANNON
PLUGS
GENERAL CATALOG
CANNON ELECTRIC DEVELOPMENT COMPANY, LOS ANGELES, CALIF.
More than 14,000
CONNECTOR ITEMS
NOW—EACH A STANDARD
CANNON PLUG

Cannon has developed and built countless specialized connectors to meet the specific needs of many industries including aviation, radio, power and motion pictures.

Today these once special items are Standard Cannon Plugs. They are available in many variations for any industry that has a problem in complex and concentrated wiring.

If you have a corner to cut or a schedule to beat in the radio, instrument or general electrical fields it is more than likely that a Cannon Connector will meet your special needs. Write, telling us your problem, and we will supply catalogs and bulletins explaining the Cannon line in detail.

ARMY E NAVY

CANNON ELECTRIC

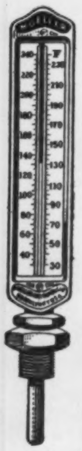
CANNON ELECTRIC

Cannon Electric Development Company, Los Angeles 31, California

Canadian Factory and Engineering Office: Cannon Electric Company, Limited, Toronto

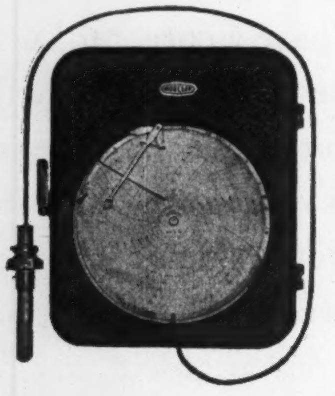
REPRESENTATIVES IN PRINCIPAL CITIES — CONSULT YOUR LOCAL TELEPHONE BOOK

MOELLER
PRECISION
GRADE
INSTRUMENTS
☆



MOELLER MERCURY THERMOMETERS
Made with "Moeller Glass Red Reading Column," making them easy to read under varying light conditions, at a considerable distance and over a wide range.

MOELLER DIAL THERMOMETERS. Made in various scale ranges up to 1000°F. or equivalent. Metal and Phenolite cases.



MOELLER RECORDING THERMOMETERS
Furnished in various ranges up to 1000°F. or equivalent. Round or square cases.

Also HYGROMETERS
RECORDING PSYCHROMETERS
BAROMETERS HYDROMETERS
MARINE INSTRUMENTS, ETC.

ARMY E NAVY

Write for catalog.

MOELLER
INSTRUMENT COMPANY
132nd STREET and 89th AVENUE
RICHMOND HILL NEW YORK
Sales Representatives in Principal Cities

of the ordinary strain gage includes a component due to the strain normal to the orientation of the gage. The ratio of the unexpected component to the ordinary component is termed the gage transverse sensitivity constant, β. The effect of β upon the indicated circles of strain and stress is then developed.

It is shown that for all values of β the indicated circle diagram is still a circle but of a new diameter. Thus is completely explained the erratic measurements of the Poisson strain and a class of gages suggested which, by the proper (and available) choice of values of transverse sensitivity, yield directly shear strain or stress, normal strain, normal stress, or lateral extension, as β takes the values of -1, 0, $+\mu$ or $+1$, respectively. Nearly all current strain gages, either of a wire or composition construction, have transverse sensitivities other than the four most useful values cited. A general method is indicated for evaluating β and correcting for known sources of error, such as the calibration of gages on a material of one value of Poisson's ratio, μ, and using them on material possessing a different value of μ.

Relations Between the Notched Beam Impact Test and the Static Tension Test

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

C. W. MacGREGOR and J. C. FISHER,
Massachusetts Institute of Technology, Cambridge, Mass.

The notched beam impact test has been of considerable value in determining the effect of various metallurgical and mechanical conditions on the suitability of materials for different applications. Experience has demonstrated that the effect of some of these conditions can not be detected by the ordinary form of tension test.

The notched beam impact test has always been difficult to correlate with other forms of tests. In order to correlate it with the tension test, the authors have made use of true stress and strain values in contrast to the more commonly employed stresses and strains which are referred back to the original dimensions of the test bar.

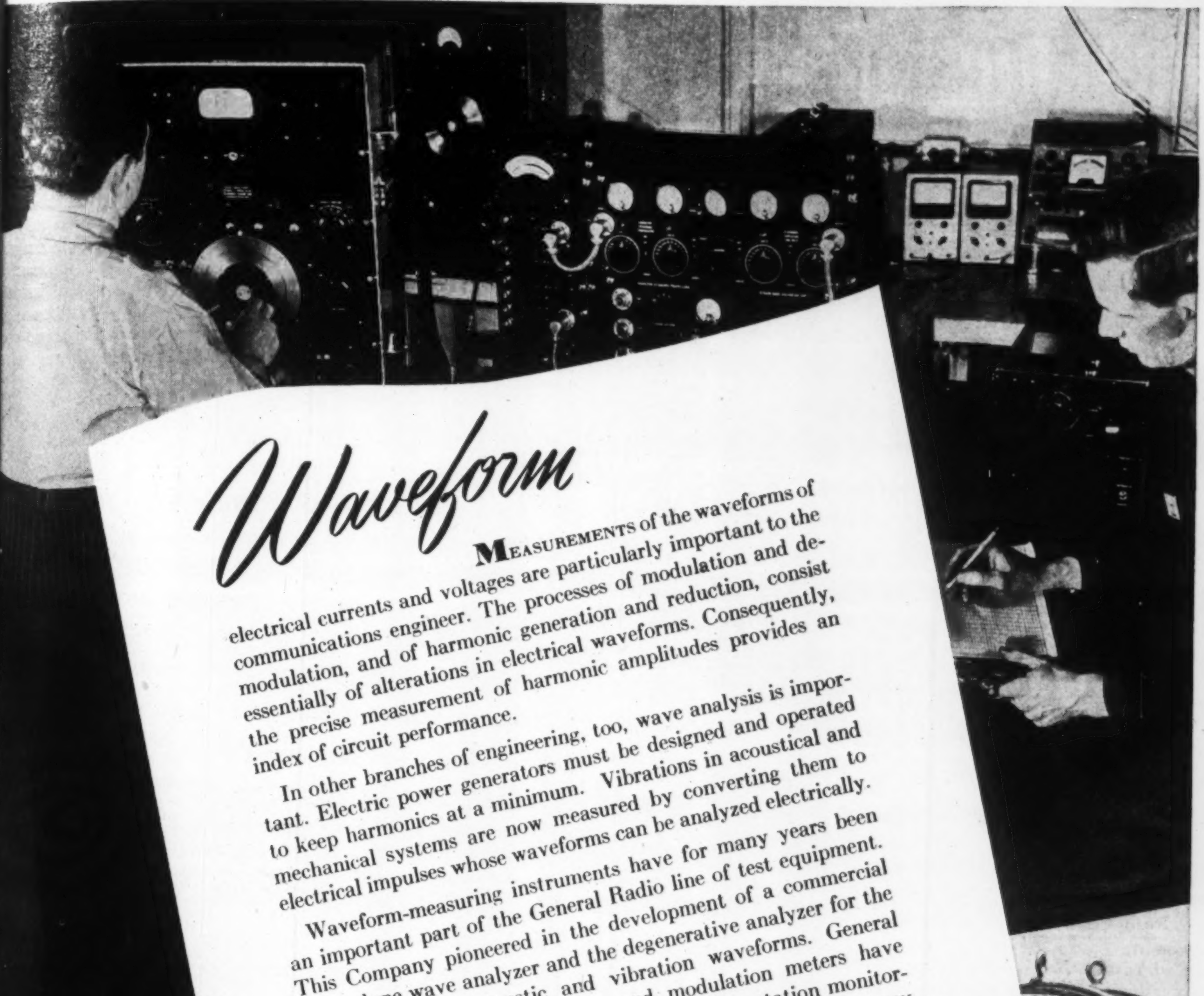
An experimental program is described in which the energy per unit of deformed volume from notched beam impact tests is compared with the energy per unit of volume as obtained from static tension tests of the true stress-strain type on plain and notched specimens. The results are compared for several steels under various conditions of heat-treatment and testing temperature.

The authors conclude that:

(1) A reasonably good correlation exists between the notched beam impact test and the static notched tension test when true stress-strain values are employed. Both forms of test display essentially the same effects of drawing and testing temperatures on the specific energy for fracture.

(2) While the main characteristics of the notched beam impact test in these experiments appear to be due to the notch rather than to the testing machine speed, the duration of the test is important where such effects as strain aging are pronounced. For a material subject to such changes in properties during the test, the duration of the tension test must approach that of the impact test in order for the correlation mentioned in (1) to hold. It also is apparent that when tests are conducted at temperatures considerably in excess of those employed in these experiments (about 180°C.), or when low melting alloys are investigated at normal temperatures, the testing speed is of considerable importance.

(3) Although the notched beam impact test appears to correlate with the notched static tension test better than with the uniform static tension test, this does not detract from the great value and significance of the tension test on uniform specimens. The latter are especially important where correlations are desired between tension values and



Waveform

MEASUREMENTS of the waveforms of electrical currents and voltages are particularly important to the communications engineer. The processes of modulation and demodulation, and of harmonic generation and reduction, consist essentially of alterations in electrical waveforms. Consequently, the precise measurement of harmonic amplitudes provides an index of circuit performance.

In other branches of engineering, too, wave analysis is important. Electric power generators must be designed and operated to keep harmonics at a minimum. Vibrations in acoustical and mechanical systems are now measured by converting them to electrical impulses whose waveforms can be analyzed electrically.

Waveform-measuring instruments have for many years been an important part of the General Radio line of test equipment. This Company pioneered in the development of a commercial heterodyne wave analyzer and the degenerative analyzer for the measurement of acoustic and vibration waveforms. General Radio direct-reading distortion and modulation meters have greatly simplified the problem of broadcasting station monitoring and maintenance. In addition, the present line includes many types of wave filters and a continuous-film recorder for oscillographic work.

Up-to-the-minute design and high quality construction are the reasons why General Radio waveform-measuring equipment is used in the world's leading laboratories.

Because all our facilities are devoted to war projects, these instruments are at present available only for war work.

GENERAL RADIO COMPANY Cambridge 39, Massachusetts
NEW YORK CHICAGO LOS ANGELES

CORROSION-PROOF

Photo Courtesy
Bell Aircraft
Corporation

with

KESTER ROSIN CORE SOLDER

- Corrosion—with terminal resistance and countless complications following in its wake—is "licked before it starts" when electrical connections are made permanent and secure with Kester Rosin-Core Solder.
- At Bell Aircraft and other plants coast to coast—building and assembling stout-hearted electrical units of every description—this important characteristic of Kester Rosin-Core Solder is helping to make American fighting equipment the finest in the world.
- Not only does the plastic rosin flux in Kester Rosin-Core Solder halt corrosion; it will not injure insulating material, disintegrate, or lose its fluxing power in any way, regardless of temperature extremes. That makes it standard at air bases everywhere—in Arctics and Tropics alike.
- All Kester fluxes are stable and scientifically correct. The acid flux in Kester Acid-Core Solder, used for general applications, gathers no moisture and assures a tight, clean, permanent union under all operating conditions.
- Kester's 45 years of highly-specialized solder experience is at your service, particularly in the selection of the proper combination of flux and alloy, strand and core size, best suited to every requirement. Write Kester engineers fully, without obligation.

☆ BUY WAR BONDS ☆

KESTER SOLDER COMPANY
4216 Wrightwood Avenue, Chicago, Illinois
Eastern Plant: Newark, N.J.
Canadian Plant: Brantford, Ont.

Finest Quality
FOR
45
YEARS
1899-1944
KESTER SOLDER

KESTER
Cored Solders
STANDARD FOR INDUSTRY

results from other forms of tests such as torsion tests, combined stress tests of many kinds, metal forming operations such as drawing, rolling, etc. It is evident that no one form of tension test is the best for all purposes. The notched tension test seems to be particularly useful in those applications where the notched beam impact test has proved of value.

(4) While the notched static tension test takes longer to perform than the standard notched beam impact test where total energies only are determined, it has the added advantage of supplying stress-strain data not obtainable in the impact test. It appears that the energy per unit of deformed volume (specific energy) from the notched beam impact test is of more fundamental significance than total energy. If the former is determined in the impact test the time consumed is usually in excess of that required for the notched static tension test.

Static Testing and Its Relation to Stress Analysis

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By W. H. BONELL
Lockheed Aircraft Corporation, Burbank, California

The common methods of static testing of airplane structures and the function of static tests as a method of stress analysis are discussed. The large amount of money which must necessarily be spent to satisfy the requirements of procurement agencies may be utilized to develop better methods of analysis or to determine the limitations of empirical and analytical methods. . . . A description of the test equipment most commonly used and an outline of the most frequent tests encountered are included in the paper. The advantages and disadvantages of the equipment in general use for producing the loads, measuring the stresses and determining the allowable stresses are discussed.

Stress Measurement by X-ray Diffraction

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

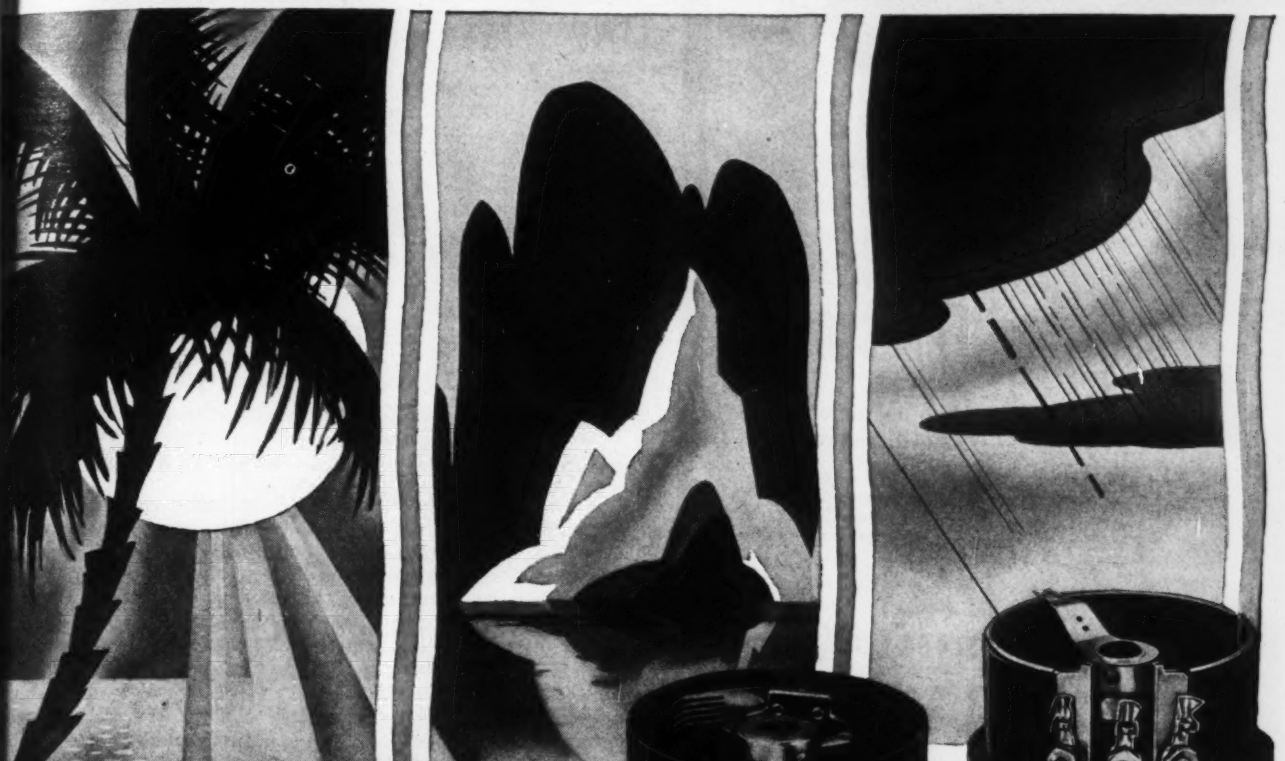
By JOHN T. NORTON and D. ROSENTHAL
Massachusetts Institute of Technology, Cambridge, Mass.

In recent years the X-ray diffraction method for the measurement of stresses in metals has received considerable development and has been applied to practical problems. The method makes use of the interatomic distance in the crystalline metal as a gage length and measures strain at the metal surface in terms of this length. By a combination of the strain measured in different directions, the surface stresses can be calculated.

The X-ray technique for the measurement of the strain involves the use of an X-ray tube and camera combined into a single unit such that the large diffraction angles can be recorded and measured with a high degree of precision. A reference powder of known atomic spacing is used on the surface of the specimen to standardize the technique. In order to measure the stress in a particular direction, two X-ray pictures are necessary, one normal to the surface and another inclined to the surface at a known angle. To measure two stresses at right angles to one another, three pictures are necessary, one normal and two oblique. If the directions of the surface stresses chosen are not principal stresses, the latter can be found by taking a third oblique picture.

An important problem in the X-ray stress measurement is the choice of the appropriate elastic constants to use in the calculation of the stress from the measured strains. In the case of steel, direct calibration shows that the ordinary

UNDER *ANY* TRYING CONDITION



More Purchases of War Bonds Will Help Shorten The War

Tropical heat, moisture, vibration, etc. . . .

DeJur wire-wound potentiometers provide maximum service and efficiency. Rugged, durable and dependable . . . engineered to meet rigid government requirements. There's a type to fill your bill . . . or we'll build to special resistances. Technical data sent upon request. Our engineers will gladly assist you.

ARMY E NAVY

Awarded for Excellence in Production and Quality of Material

De Jur-Amsco Corporation

SHELTON, CONNECTICUT

NEW YORK PLANT: 99 Hudson Street, New York City • CANADIAN SALES OFFICE: 560 King Street West, Toronto

CAN YOU SEE AROUND
A
CORNER
?

Inspection of hard-to-get-at places now made certain and accurate with the help of

WAPPLER
INDUSTRIAL TELESCOPES

Write for our Booklet: "Precision Instruments for the Exacting Inspection of Internal Surfaces."

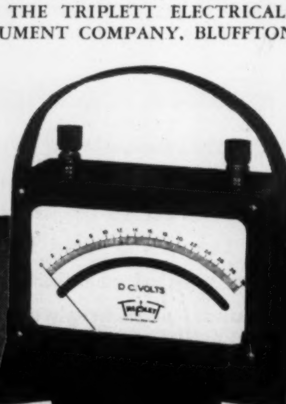
For prompt action and our recommendations, include drawing of part to be inspected, or preferably the part itself.

A.C.M.I. TRADE MARK

Industrial Division
AMERICAN CYSTOSCOPE MAKERS, Inc.
FREDERICK C. WAPPLER, Pres.
1241 Lafayette Ave (Bronx) New York, U.S.A.

MODEL 625—0-30 D.C. VOLT METER

This is one of today's most popular portables. The new design has a hinged dial cover for added protection; insulated molded case and hand calibrated mirror scale 4.58" in length. Furnished to an accuracy within one-half of 1%. THE TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, O.



TRIPLETT

"mechanical" constants used for a poly-grain material give approximately the correct value of the stress. In the case of copper, however, entirely fictitious values must be used to make the mechanically measured values agree with those measured by X-rays. This situation presents a very interesting problem in the deformation of a polycrystalline metal.

Various conditions within the metal influence the sharpness of the X-ray diffraction lines. With sharp continuous lines, the reproducibility of the stress measurement is about ± 1500 lbs./in^2. Coarse grain size causes discontinuous lines and non-homogeneous deformation of the crystals causes broadening of the lines. Both circumstances reduce the precision of the method.

The particularly valuable features of the method are the facts that it is non-destructive and that it measures only the elastic part of the strains.

New Combustion-Control Methods for All Standard Fuels

Abstract of paper presented at Annual Meeting of A.S.M.E. New York, Nov. 28-Dec. 3, 1943, under auspices of Fuels Division.

By ROBERT REED, Engineer, John Zink Co., Tulsa, Okla.

As a result of extensive study and field experience with combustion problems, the author offers suggestions for increasing the accuracy of combustion control in all types of furnaces and with all types of standard fuels. This is accomplished by overcoming the existing limitations of flue-gas-analyzing methods either by recorded CO_2 concentrations, or by Orsat analysis. Curves are given which provide a simple means for determining "excess air by CO_2" and "excess air by O_2" by the use of which excess-air control can be quickly adjusted for any change in fuel to obtain unimpaired combustion. The importance of determining the presence of aldehydes in flue gases is recognized and a simple test using basic fuchsin dissolved in a cold saturated aqueous solution of SO_2 is given. This check on combustion may save considerable fuel, and a great deal of mechanical difficulty with furnaces.

Some Aspects of Observing the Performance of Large Machinery Under Operating Conditions

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By J. H. MEIER, Bucyrus-Erie Co., Milwaukee, Wis.

Field performance tests on large excavating machines involve the measuring and recording of a number of operation characteristics, as forces and moments transmitted through machinery parts, the deflection of shock absorbers, and the motor and shaft speeds at which they occur. In addition, it is important to know how these phenomena are related to the phase of operation and to the manipulations of the operator.

Severe mechanical vibrations and strong electrical and magnetic fields are often encountered on this type of heavy equipment. Therefore, remote recording with instruments on the ground, protected from these disturbances, is best suited for such tasks.

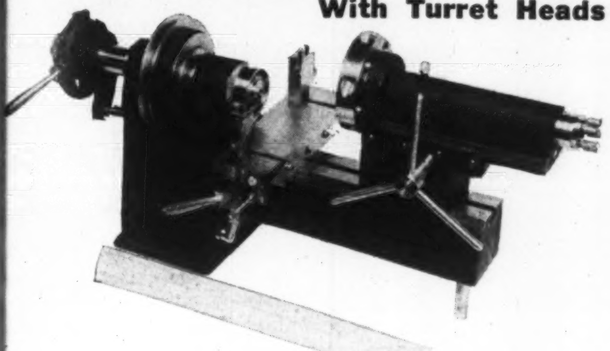
The long trailing cables necessary for such tests bring about a number of problems. Bridge circuits are described which are best suited to overcome the difficulties. The effects of lead losses are discussed and methods are given by which they can be checked and eliminated from the test results.

A simple deflection indicator for investigating shock absorbers and a slipring and brush arrangement serving two rotating Wheatstone bridges are described. Formulas are derived for the field calibration of bridge and amplifier-

MMEDIATE DELIVERY . . .

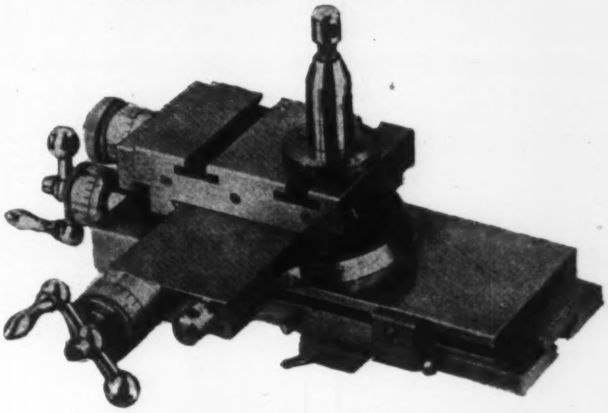
NSTRUMENT PRODUCTION LATHES

With Turret Heads



Two Sizes—3/16" and ½" Bar Capacity
9" Bed and 4" Swing
Both Sizes Have Lever Collet Closers

COMPOUND SLIDE REST



English or Metric Screw Feed
Lever Attachment Available

For Precision Work on

AIRCRAFT INSTRUMENTS RADIO INSTRUMENTS CAMERA INSTRUMENTS METER INSTRUMENTS
ELECTRICAL INSTRUMENTS AND TIMING DEVICES

R. P. GALLIEN

AIRCRAFT INSTRUMENT PRECISION EQUIPMENT . . . TOOLS AND SUPPLIES
220 WEST FIFTH STREET, LOS ANGELES, CALIFORNIA

PRECISION NAXON BUILT PORTABLE ELECTRIC INSTRUMENT WASHER

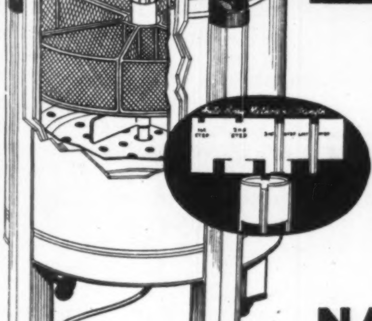
Filings, burrs, etc., from brass or copper screw machine parts salvaged in sediment trap will soon pay for this machine.

Use your own proven solvent or cleansing liquid such as Oakite, soap, powder solution, carbon tetrachloride, trichlorethylene, etc.

Only $80

Complete with Trays and Cover

Same instrument with thermostatically controlled heating element for use with low-cost solutions where constant temperature is required, Model C742-B, $100.00.



THOROUGHLY AND SAFELY CLEANSES THE MOST DELICATE MECHANISMS AND SMALL PARTS

1. No Abrasions! No Bumping! No Scratching! No Tumbling! Absolutely no abuse because there is no moving of the most delicate parts or mechanisms.

2. Cleansing liquid circulates through complex and odd shaped instrument assemblies—work remains stationary.

3. Keeps disassembled parts together; no mixed or missing parts.

4. Work comes out like new.

5. Compartments can be lifted out. Larger parts can be just as thoroughly cleaned.

6. Drain well at bottom for dirt elimination.

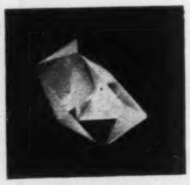
WRITE FOR LITERATURE

AIRCRAFT INSTRUMENT DIVISION

NAXON UTILITIES CORPORATION

Engineers and Manufacturers of Precision Electrical Devices Since 1922
2101-11 WALNUT STREET, CHICAGO, ILLINOIS
World's Leading Manufacturer of Portable Electric Washers

OPTICAL ELEMENTS
... for your instruments



AMICI PRISM

Glendale produces prisms, lenses, mirrors and other optical elements to exact specification for your instruments.

We specialize in making precision optics only, and as a result of our specialization *Glendale* units ensure that high degree of accuracy which is the first consideration of the experienced user of any instrument involving optics. Our products include:

- Prisms
- Lenses
- Flats
- Mirrors
- Shade Glasses
- Reticles

Optical Units for

BINOCULARS • SEXTANTS • OCTANTS • TELESCOPES (sighting)
GYROSCOPES (mechanisms) • DRIFT SIGHTS • DRIFT METERS

and Many Other Instruments

GLENDALE OPTICAL COMPANY
Makers of Precision Optics
250 PENNSYLVANIA AVENUE BROOKLYN, N. Y.

For Your Laboratory, Product, or Production Line
CONSTANT VOLTAGE
Steadi-Volt

★Output voltage 110, 115, 120; 1% accuracy. ★Input range 95 to 130 volts. ★Independent of load. ★No moving parts. ★High efficiency. ★Power factor better than 90%. ★Negligible time constant. ★Sizes from 15 to 2000 watts.

UNITED TRANSFORMER CO.
150 VARICK STREET ★ NEW YORK, N. Y.
EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"

meter combinations and the methods of calibration are described in detail.

The various methods of recording and their respective merits are briefly discussed.

Although these circuits and methods were developed for the analysis of the performance of excavating equipment, they are readily adapted to investigations on other large machines or bridge structures.

The Bonded Wire Gage Torquemeter

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By ARTHUR C. RUGE, Ruge-deForest, Cambridge, Mass.

The basic principles of the wire gage torquemeter are discussed from the standpoints of (1) elimination of effects due to thrust and bending, (2) temperature compensation, and (3) effect of erratic contact resistance at the slip rings. Typical measuring circuits are given and practical limits of accuracy are suggested. Precise measurement of thrust in a rotating member is a unique possibility deriving from the same principles.

A small torquemeter embodying these principles was demonstrated in operation with both static and dynamic measuring instruments of commercially available types.

Applications of the Brittle Lacquer Method in the Stress Analysis of Machine Parts

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By M. HETÉNYI and W. E. YOUNG
Westinghouse Research Laboratories, East Pittsburgh, Pa.

The paper illustrates the application of the brittle lacquer method in a variety of problems which range from small refrigerator flapper valves to huge gear tooth models, including such items as torsional couplings, gear housings and generator brackets. The characteristic features of the method are discussed at some length and the results checked, whenever possible, against those obtained by other means.

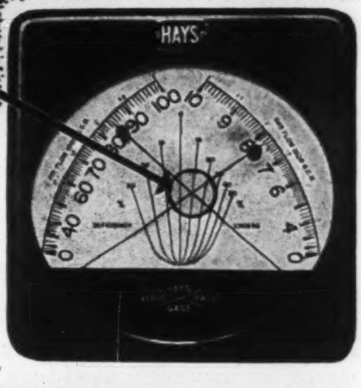
Gas Turbines and Turbosuperchargers

Abstract of paper presented at Annual Meeting of A.S.M.E. New York, Nov. 28-Dec. 3, 1943, under auspices of Aviation Division.

By SANFORD A. MOSS, Consulting Engineer, Supercharger Engineering Division, General Electric Co., West Lynn, Mass.

Generation of power by direct action of products of combustion on a turbine wheel has been an engineering dream for a century and a half. The remarkable records of the Consolidated "Liberator," the Lockheed "Lighting" and the Republic "Thunderbolt," all equipped with turbosuperchargers, indicates the spectacular developments in this field. Since his University days, Dr. Moss has been associated with many of the developments relating to the gas turbine and particularly to the perfection of the airplane-engine turbosupercharger. It is from the viewpoint of an active contributor to these developments that Dr. Moss reviews the history of the gas turbine and its potential use as a prime mover. A comprehensive bibliography (48 headings) assists in outlining the evolution of each component of the modern gas turbine from its earliest inception. United States and foreign gas-turbine research projects are touched upon, and then details of advancements in such items as nozzles, compressors and the like are discussed. While the gas turbine as a prime mover has not been ap-

X MARKS *the* SPOT



Where the pointers cross in the gage illustrated the percentage of *air excess* is indicated. Scales can be furnished that will show in similar manner the exact ratio existing between the flow of gas and the flow of oil or other measurable fluid or

HAYS VISIO-RATIO GAGE

between any two of the following functions: pressure, draft, suction, temperature (up to 1000°F.) speed in R.P.M. or inches per minute, position, level, etc. Has many uses in steel mills, gas producing plants, heat generating plants, CO_2 generating plants, sewage plants, chemical plants, kilns, air-conditioning and others. Write us and learn how this newest Hays gage may be applied to your own flow measurement problems.

THE HAYS CORPORATION

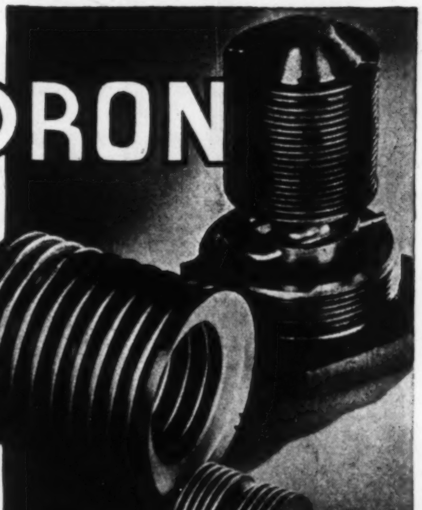
SINCE 1901

COMBUSTION INSTRUMENTS AND CONTROL

MICHIGAN CITY, INDIANA, U.S.A

HYDRON

HYDRON Metal Bellows



Metallic Bellows

● We manufacture bellows and bellows assemblies ready for installation in steam traps, relief valves, temperature regulators, pressure regulators, air valves, and other automatic temperature and pressure controls. Complete engineering service.

CLIFFORD MANUFACTURING CO.

CHICAGO	564 East First Street	DETROIT
221 N. LaSalle Street	BOSTON, MASS.	1847 W. Bethune Ave

THE TACHOMETER
You've Been Waiting For

MODEL TSG–6

Formerly used as a part of our Chronotachometer . . . now being sold as a separate unit

This efficient Tachometer has been used for some time as a part of our Chrono Tachometer, in combination with a particularly accurate revolution counter and timer of our own manufacture. We are now offering it for the first time as a separate unit.

Its outstanding advantages are as follows:

ACCURATE to within 10 R.P.M. — between 200 and 3500 R.P.M.

READABLE 6″ Dial. 66″ Scale length. Hand makes 3½ revolutions.

ELECTRIC DRIVE GENERATOR screws to standard S. A. E. tachometer fitting. 3 wires extend to tachometer. Distance limited only by wire size. 1 generator drives 2 tachometers.

RUGGED — Will stand severe use, abuse and vibration.

Dials graduated to suit special needs are available.

Address I-13

THE STANDARD ELECTRIC TIME CO.

"Split-Second Measurement by Standard"

SPRINGFIELD, MASSACHUSETTS

PATENT PENDING

Save Metal with These

HERMAN PRECISION GRANITE

SURFACE PLATES

More than just a satisfactory substitute for plates made out of war-vital metal... Herman PRECISION GRANITE Surface Plates are a *distinct improvement—definitely superior* in every respect. Cut from solid blocks of natural granite—far harder than any tools which will be used on them—they are absolutely warp-proof and remain accurate to 1/10,000 inch overall. Because they do not become charged with abrasives, even when used near grinding machinery, wear on tools is virtually eliminated. Both rust and corrosion-proof, they are practically indestructible. Already in nation-wide use in scores of important shops. Write today for full details on how Herman PRECISION GRANITE Surface Plates can increase production efficiency and economy in your shop.

STANDARD SIZES AND WEIGHTS

12" x 18"...75 lbs.	20" x 30"..275 lbs.
18" x 24"..160 lbs.	24" x 35"..480 lbs.

Special Sizes on Request. Prices are Reasonable.

Write for Illustrated Descriptive Circular.

THE HERMAN STONE CO.

1239 Leonhard Street **Dayton 4, Ohio**

PERMOPIVOTS AFTER TEST
ORDINARY PIVOT AFTER TEST

A few reasons why PERMOPIVOTS are now

THE ACCEPTED PIVOT

with precision instrument makers everywhere

PERMOPIVOTS have emerged with an excellent record from both laboratory tests and long periods of actual use under trying conditions. As a result PERMOPIVOTS are now generally accepted by manufacturers as the pivot that keeps precision instruments accurate longer.

PERMOPIVOTS cannot rust or corrode. Their satin-smooth tip is non-abrasive . . . eliminates abrading particles of wear. Oil is eliminated by PERMOPIVOTS extremely low coefficient of friction.

Write today for your copy of this informative booklet

PERMOMETAL

PERMO, Incorporated

Manufacturing Metallurgists

6415 Ravenswood Ave., Chicago 26, Ill.

plied except in isolated cases (such as the Neuchatel, Switzerland, 4000-kw. emergency gas-turbine plant and the Swiss Federal Railway gas-turbine locomotive) partial gas-turbine cycles are in somewhat extensive commercial operation. Examples of these are the Diesel exhaust-gas turbine, the Diesel boiler cycle and the divided-manifold cycle.

Some Phases of Structural Research at Goodyear Aircraft Corporation

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By E. L. SHAW, Goodyear Aircraft Corporation, Akron, O.

Considerations in designing stress models in general are presented with various means for scaling down the elastic characteristics of prototype structures including attendant means for accurately measuring strains and stresses. The expected accuracies for this type of model testing including those associated with model design, model construction, and model testing, are presented to be exceedingly high and corresponding closely with the analytical treatment for the prototype structure. Types and limitations of different loading for such a model testing are discussed. Experimental results in the field of general structural instability of cylindrical framework are presented along with considerations in the design of such model representation. The effect of fatigue on certain composite structures shows interesting conclusions applicable to the general field of structural design.

More A.S.M.E. Papers in February

Sixteen abstracts crowded out of this issue at last minute on account of WPB paper tonnage limitations. See publisher's statement on page 68. If possible, all sixteen will appear in the February issue.

Alnor type 1760

PORTABLE PYROMETER

a long scale, sensitive accurate portable pyrometer, ideal for laboratory and similar service.

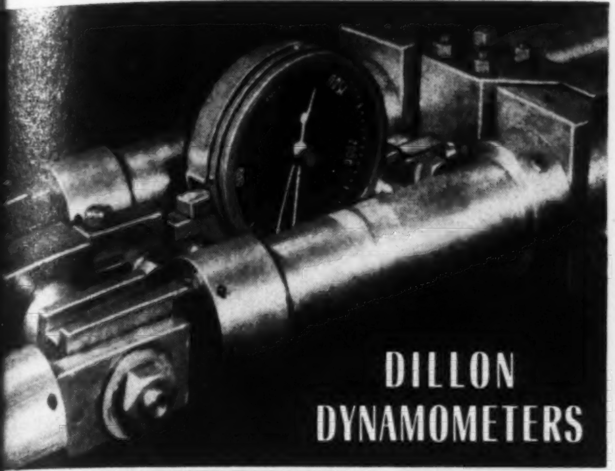
Type 1760 Portable Pyrometer with the special thermocouples provided, affords extremely accurate temperature readings. Long mirror scale and knife edge pointer make accurate readings easy. High internal resistance allows moderate variation in thermocouple size, and length of connecting wire, without affecting accuracy. Internal automatic cold end compensator is standard equipment.

Type 1760 is available with single range and two range scale. Standard ranges from 0-300 deg. F. to 0-2500 deg. F. With rare metal thermocouple, range 0-3000 deg. F. Write for Bulletin 2416 with complete listings of all types.

ILLINOIS TESTING LABORATORIES, INC.

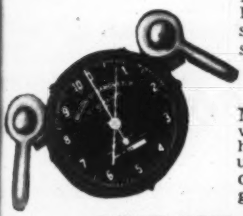
142 WEST HUBBARD STREET

CHICAGO 10, ILLINOIS



FOR VERSATILE TENSION MEASURING

Above view shows DILLON DYNAMOMETER hooked into mechanical assembly to indicate exact amount of friction encountered by packing in hydraulic cylinders. Just one of scores of uses for this handy instrument.



COMPACT—ACCURATE

Measures only 8¼"x6¼"x3"—weighs 8 lbs. 4 oz. Has Maximum hand. Thousands in use—capacities up to 20,000 lbs. Not injured by overload, easy to use. Priced *low*—good delivery.

WRITE DEPT. RD FOR LITERATURE

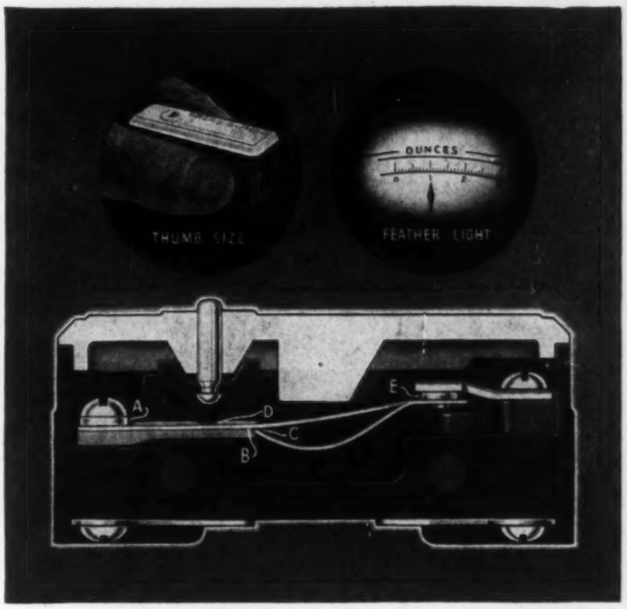
W. C. DILLON & CO., INC. 5410 W. HARRISON STREET
CHICAGO, ILLINOIS

PERFECTION
from a
HUNDRED PAIRS
OF HANDS
ARMY E NAVY

The "human element" so consistently mentioned as a necessary part of every great accomplishment, is exemplified in the high quality of Thordarson transformers. From engineering laboratory to final inspection, countless pairs of hands and minds work in harmony to bring about in each complete transformer a coordination of effort that makes for superb performance.

THORDARSON
ELECTRIC MFG COMPANY
500 WEST HURON STREET, CHICAGO, ILL.

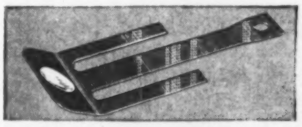
Transformer Specialists Since 1895
ORIGINATORS OF TRU-FIDELITY AMPLIFIERS



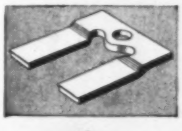
Why These Basic Principles of Micro Switch Design Assure You . . .

- **Longer switch life than you will ever need**
- **Absolutely precise and accurate repeat operation**
- **40 grams contact pressure—lightning-fast contact action**

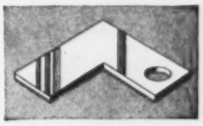
The Micro Switch design incorporates features that provide desirable performance characteristics not generally found in snap-action switches . . . The heat-treated beryllium-copper spring bends in the same direction as the operating plunger—no reverse bends—no "oilcan" action . . . gives longer switch life—accurate repeat action—increased contact pressure—lightning-fast action—millions of operations on minute movement and force differentials. It is the choice of design engineers for all types of sensitive instruments.



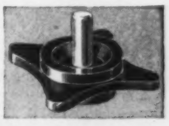
The beryllium-copper spring is made in one piece. It is gauged to an accurate .0085" thickness; has high resistance to fatigue. Ends of compression members are finished to provide an extremely low friction bearing. Contact end of the spring is fitted with a riveted radius type contact of 99.95% fine silver. It moves at a speed of 3/1000ths to 5/1000ths of a second with a rolling action and extremely high pressure.



Short spring members pivot in patented V-grooves of this sturdy brass anchor. Note the special shape of these grooves, which reduces friction to a minimum.



Stationary contact is a flat inlay of 99.95% fine silver. This construction assures ample over-load capacity and maximum heat dissipation.



Operating plunger is a highly polished stainless steel pin imbedded in an accurately moulded star-shaped Bakelite head. Provides long over-surface path to live parts, thus insuring freedom from electrical leakage. Plunger head cannot rotate within the housing, insuring against any variation in point of operation.

If you would like to know more about the Micro Switch, send for the two Handbook-Catalogs illustrated here—No. 60, which covers Micro Switches in general; and No. 70 which deals with specific Micro Switches for use in aircraft.

© 1942

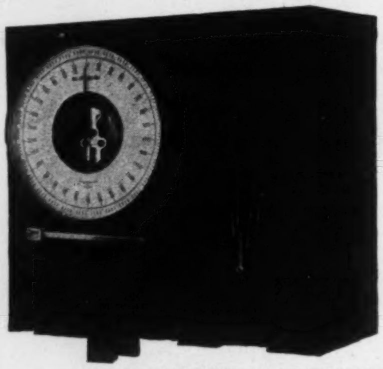
Micro Switch is a trade name indicating manufacture by Micro Switch Corporation

MICRO MS SWITCH

Manufactured in FREEPORT, Illinois, by Micro Switch Corporation
Branches: 43 E. Ohio St., Chicago • 11 Park Place, New York City
Sales and Engineering Offices: Boston • Hartford • Los Angeles

KRON

WEIGHT CONTROL AND FORCE MEASUREMENT INSTRUMENTS



Our latest—
KRON DRAW BAR DYNAMOMETER SCALE
for
Aircraft
Control Cable
Testing

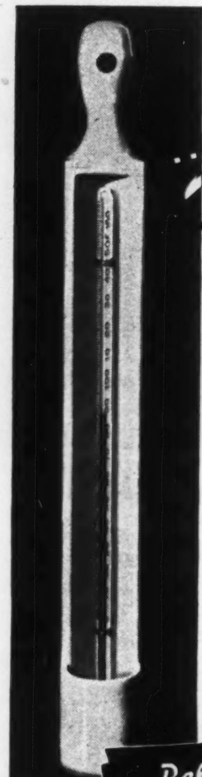
ENGINEERED APPLICATIONS

Our engineering staff has designed literally hundreds of engineered applications of KRON Scales of all types for special processes and unusual weight control problems.

KRON SCALES ARE BUILT IN CAPACITIES FROM 50 to 40,000 lbs. KRON LEVERS are so designed that they can be adapted for practically any size or shape of platform, hopper or tank. KRON dials can be furnished with or without tare beams on column and also with cabinet having one to seven increments of unit weights.

WEIGHT PRINTERS, RECORDING DEVICES, PHOTO-ELECTRIC CELLS, MERCURY or MAGNETIC SWITCHES, VARIABLE CAPACITANCE CONTROL, and many other accessories and control systems can be supplied for engineered applications.

The KRON CO.
1728 Fairfield Ave. Bridgeport 5, Connecticut
Offices in all principal cities



... AN H-B THERMOMETER WITH
New PORCELAIN CASE

New, simplified design incorporates case, handle and cup in one-piece, corrosion-proof porcelain. Units now available have a range of 0° to 160° F. with the red liquid filled thermometer having one-degree graduations. Other ranges can be supplied up to 750° F., if desired.

Constant refinement in design and construction as well as a wide fund of application experience are yours when you specify H-B instruments—Thermometers, Thermo-Regulators, Relays. Write!

H-B INSTRUMENT COMPANY
2525 No. Broad St., Philadelphia 32, Penna.

Rely on **H-B** *Instruments*
THERMOMETERS • HYDROMETERS
THERMO-REGULATORS • RELAYS

PRECISION TO THE "Nth" DEGREE

Perfect co-ordination of skilled minds and hands in a well knit organization with 20 years of radio manufacturing experience has been the secret of MERIT'S success in building precision equipment to the most exacting specifications.

Now manufacturing for every branch of the Armed Services.

Suppliers of component parts for the famous SCR-299 mobile unit.

PRODUCTS OF MERIT

Since 1924

Transformers — Coils — Reactors — Electrical Windings of All Types for the Radio Trade and other Electronic Applications.

MERIT COIL & TRANSFORMER CORP.
311 North Desplaines St. CHICAGO 6, U. S. A.

HIGH SPEED MOTORIZED VALVES

CHOICE of OPERATION
Automatic or Remote Manual

2 OPEN CLOSE
OPEN
CLOSE
Push Button

110-220 V. AC or DC

2-contact measuring instrument

Use any standard temperature, pressure, flow or level measuring instrument equipped with "High" and "Low" contacts.

For remote manual opening and closing of valves, use a two-contact push button station.

STEAM CHEMICALS OIL, GAS

HANDWHEEL for EMERGENCY

GENERAL SPECIFICATIONS

Universal, reversible motor drives a power screw thru a sturdy gear reduction. Limit switch built-in. Can operate slip-stem valves up to 12" at normally used pressures.

Easily installed in inaccessible locations in either vertical or horizontal pipe lines.

May be weather-proof, explosion-proof, acid-proof, water-jacketed or supplied with minimum flow adjustment.

MAIL COUPON TODAY

3 SIZES

5 SPEEDS 2,3,4,5,7 sec.

LIFT FORCE to **550** lb.

NEW DATA
Send Catalog A3

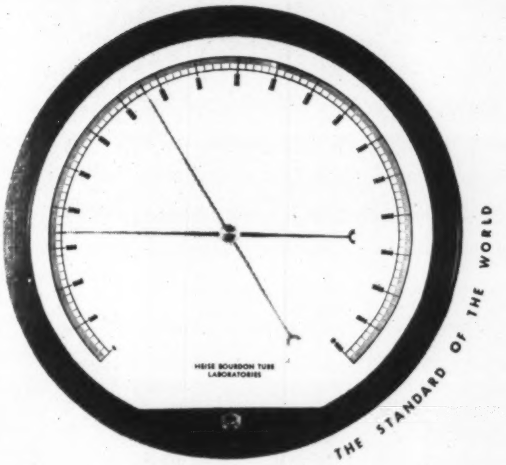
Name

Title

Firm

Address

atc *Industrial Control*
AUTOMATIC TEMPERATURE CONTROL COMPANY, INC
34 E. LOGAN STREET, PHILA. 44, PA



EVERY DAY we are shipping these precision pressure gauges to be used in place of dead weight testers. They are accurate, dependable and easy to read. Delivery—2 to 6 weeks.

RANGE FROM 0-60 lbs. to 0-10,000 lbs	
12" Dial	144.00
16" Dial	176.00

HEISE BOURDON TUBE LABORATORIES
BROOK ROAD NEWTOWN, CONNECTICUT
IN COLLABORATION WITH THE A. H. EMERY COMPANY

At last A method to measure SURFACE FINISH RESISTANCE to Digs and Scrapes

SHEAR-HARDNESS testing with the Taber Abraser is a quick, accurate method of computing comparative surface resistances to digs and scrapes and similar surface damages not caused by normal wear.

Write for Bulletin 4012 illustrating wide applications.

TABER INSTRUMENT CORP.
111 IS GOUNDRY ST., NORTH TONAWANDA, N.Y.
Designers and Builders of Precision and Scientific Apparatus

Taber
ABRASER

TODAY...
WAR
IS IN THE
SPOTLIGHT!

HERE AT SOMCO, War work now commands top billing on our production program. This is as it should be, for America's weapons of War need the precision lenses, prisms and optical flats SOMCO is so well qualified to produce.

But, tomorrow, when Victory is won, SOMCO will again produce optical equipment, improved by our war experience and with new benefits from war innovations. And, tomorrow as always, SOMCO will assume its leadership because it has never abandoned its policy of applied research.

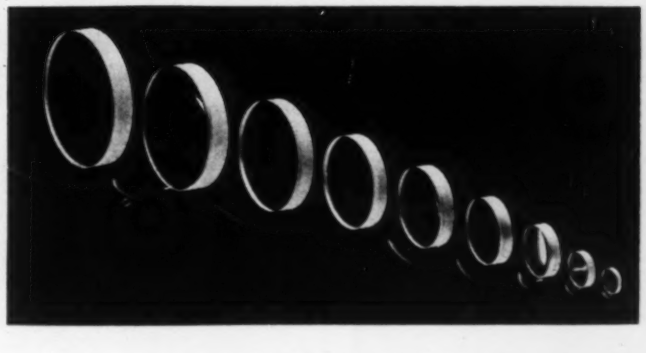
Because we must prepare for Peace while winning the war, we welcome your inquiries about your present problems and future plans. Our research, engineering and production staffs are always at your service.

SIMPSON OPTICAL MANUFACTURING CO.
3200 W. CARROLL AVE., CHICAGO 24, ILL.

PROJECTION LENSES • CAMERA LENSES • PRISMS
OPTICAL FLATS • SOUND OPTICAL SYSTEMS
AND LENS COATING FOR LOW REFLECTION

★

SPHERICAL LENSES: Spherical optics, precision polished, designed to meet the varied functional requirements of scientific optical instruments such as sights, telescopes, Fire Control and Navigational instruments, projection lenses and microscopes.



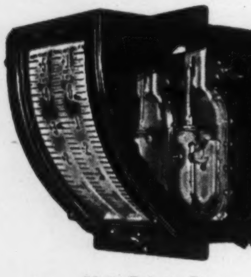
BAILEY METERS

METERS and CONTROL
for Boiler Room Service . . .

Boiler Meters Reduce fuel costs, lessen maintenance and outage, lower standby costs, and add capacity. They indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature.

Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.


Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

Coal Meter

Granular Material Meters For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

Complete Information on any of the above Bailey products will be gladly furnished upon request.

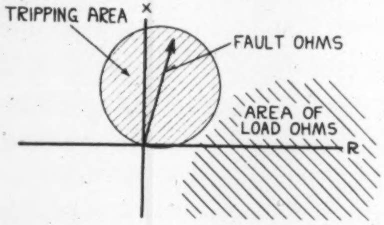
G-14

BAILEY METER
• COMPANY •
1041 Ivanhoe Rd., Cleveland, Ohio
BAILEY METER COMPANY LTD., MONTREAL

The Month's NEW INSTRUMENTS

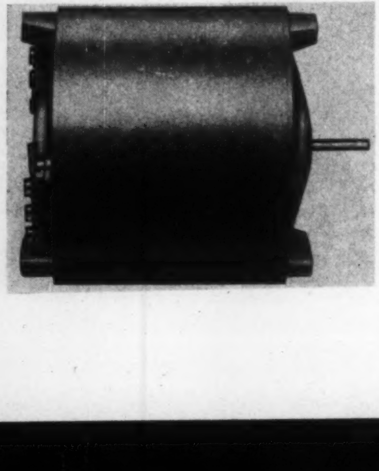
Transmission-line Relay

New high-speed distance relay of impedance type has been designed for heavily-loaded long lines. Manufacturer's announcement does not give a physical description of relay but describes it in terms of the problem and its solution, thus: Distance relays that protect electrically-long transmission lines must be able to distinguish between load impedance and fault impedance; they must discriminate between a legitimate load and a fault. Generally, fault impedance is so much smaller than normal load impedance that a relay can discriminate between the two, but if line is long and load heavy, standard impedance relay would operate incorrectly during full-load conditions. Owing to wartime power loads, more interconnections and longer lines, impedance in a short circuit often is greater than that resulting from full-load current flow. To meet these conditions, relay must not operate on surges that do not upset system-synchronism, must be provided with some different sense of perception, must trip for faults but remain undisturbed for conditions that do not pull the system out of stop. New high-speed impedance relay has this discriminating ability: new design makes use of the wide difference in phase angle that usually exists between load and fault currents on electrically-long circuits. Load currents on long lines generally are near unity power factor —fault currents lag by 60° or more. New relay's characteristics enable it to recognize not only magnitude of an impedance but impedance angle as well. — *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*



"Telegon" Unit for Low-torque Rotatable Transformer Applications

New "Telegon" unit (herewith illustrated in exact size) weighs 5 oz. Its rotor weighs only 0.06 oz. Equipped with jewel bearings, it operates with "probably less torque than any other similar unit." It has made possible a recent development in electronic control, particularly in airborne equipment: its use as rotatable transformer where only extremely low torque is available or where compactness and light weight are important requirements. Most applications of this sort call for feeding a high-frequency alternating current into the rotor excitation winding, and taking an induced voltage from the 2-phase winding, which varies roughly proportional to angular movement. This voltage is amplified and fed to a variety of devices. An "ideal application" would be field control in an Amplidyne type unit. "Type 315S-971" operates at 110-volt 400-cycle, requires input current of 0.018 amps. and input power of 1.3 watts. It has six external solder terminals. Other units are available operating from 85-volt 400-cycle or 26-volt 400-cycle sources.—*Kollsman Instrument Division, Square D Co., 80-08 45th Ave., Elmhurst, N. Y.*

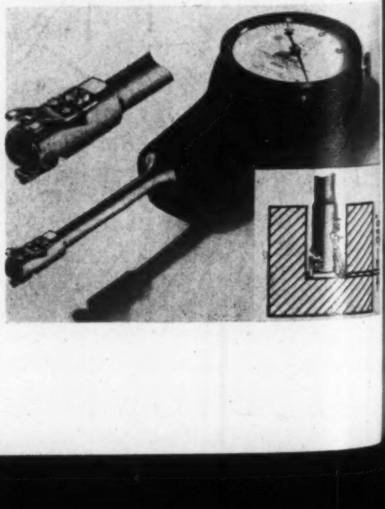


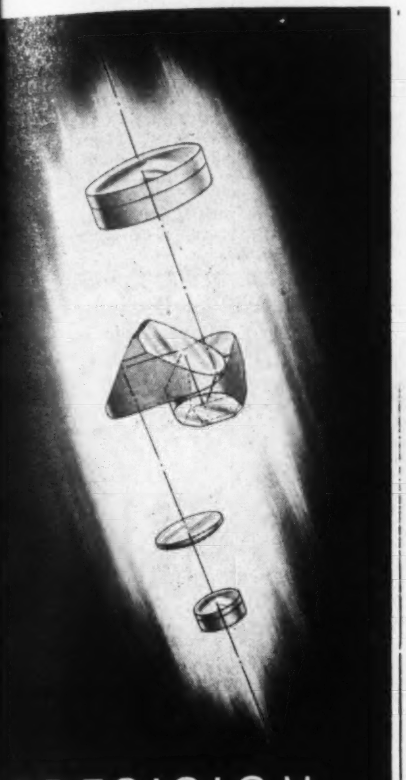
Thermocouple for Carburizing

New type thermocouple, to be known as "Carbucouple," has been designed and constructed for a cyanide carburizing in heat-treating and allied industries. It is said to feature a uniquely designed hot leg, consisting of an outer tube which has been heat-treated and surface conditioned by a special process, and an inner ceramic tube to protect thermocouple accuracy. Claims made for "Brown Carbucouple" include lower base cost, greater durability and sensitivity and assured accuracy. Prompt delivery is also assured by reason of use of non-critical materials. Extensive tests are said to have shown at least twice the life of thermocouples made with nickel tubes; also that new couple is more sensitive or responsive. Special inner tube is said to protect thermoelements throughout life of tubes, overcoming deterioration of an unprotected couple.—*Brown Instrument Co., Wayne & Roberts Aves., Philadelphia 44, Penna.*

Centralizing Type Blind Hole Gages

New "Model 1201 P-20" and "Model 1201 P-21" blind hole gages are designed to check inside diameters to within 0.030" of bottom (see diagram in illustration). Internal operating friction, lost motion and wear are said to have been practically eliminated as all moving parts in the gaging head are spring-suspended. There are no bearings or bushings. These features also permit gages to be used under adverse conditions as a reasonable amount of oil, coolant, or dirt in the gaging head does not affect accuracy sensitivity of the gage. Two auxiliary locating contacts centralize the measuring contacts diametrically across





PRECISION

...IS A HABIT WITH UNIVIS

● Millions of finest quality multifocal ophthalmic lenses . . . made to exacting precision standards . . . were the background that Univis possessed when the call came for production of precision optical elements for our Armed Forces.

True . . . new facilities and equipment had to be created, designed, built. Skills had to be converted . . . personnel trained. But the basic requirement—*the habit of precision*—was already there—an integral part of the Univis make-up. The result—unprecedented production and a remarkably high record of acceptance for Univis precision optical elements.

This priceless ***habit of precision*** is available to users of precision instrument lenses and prisms. Production for our Armed Forces, of course, is the paramount concern of Univis today. But we shall welcome the opportunity to discuss and assist in the development of your post-war products.

THE UNIVIS LENS CO.
INSTRUMENT LENS DIVISION
DAYTON, OHIO

"LUBRI-TACT" PORCELAIN-TUBE RHEOSTATS

"JAGABI" RHEOSTATS
. . . for ACCURATE Current Control

Jagabi Rheostats combine ruggedness of construction with instrument accuracy. From the smallest to the largest size, they permit the fine adjustment that is necessary for the proper control or functioning of equipment with which they are used.

Jagabi Lubri-tact Rheostats have a unique lubricated positive sliding contact and are made in four sizes and seventy-six ratings. Available also with screw adjustment and in metal-cage types for switchboard or table mounting.

Jagabi Compression Carbon Rheostats can be smoothly controlled by screw adjustment and overloads of several hundred percent are permissible for short periods of time. Four sizes in current ratings from 6 to 65 amps. up to 55 to 800 amps.

For descriptive material and data write for Rheostat Bulletin 1705-I.

JAMES G. BIDDLE CO.
1211-13 ARCH STREET • PHILADELPHIA, PA.

"JAGABI" COMPRESSION CARBON RHEOSTATS

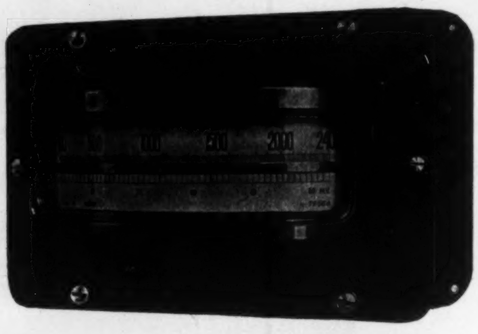
WHAT do you need in a PYROMETER?

SENSITIVITY RESISTANCE DURABILITY SIMPLICITY

Engelhard Direct Deflection Indicators have all these features . . . Accurate sensitivity to the most minute voltage variations due to suspension type construction . . . High resistance per millivolt and no appreciable error when used with thermocouples of different resistances and on connecting leads of considerable length . . . Sturdy construction, adapted to use under severe conditions without danger . . . So simple that instant readings may be made directly in either millivolts or temperatures by someone unfamiliar with the principles of pyrometry . . . On kilns or furnace installations, where "spot readings" are desirable—the Engelhard Rotary Switch permits separate readings from many points.

Write for Catalog

PORTABLE MODEL P-1


WALL TYPE W-1

CHARLES ENGELHARD, INCORPORATED
90 CHESTNUT ST. NEWARK, NEW JERSEY

DAVY JONES' LOCKER HOLDS NO THREAT FOR THIS IMMERSION-PROOF, SHOCK-PROOF TRANSFORMER

A product of the N-Y-T Service Department

Typifying the broad advances possible through close collaboration between the Army, Navy and N·Y·T engineers, this unit conforms to the most exacting requirements of modern military equipment.

Embodying the very latest in design, its proportions have been engineered to permit maximum performance, while utilizing only a minimum of space.

The immersion-proof case has been custom-built to do a specific job, further illustrating the policy of the N·Y·T Sample Department of meeting individual mechanical and electrical requirements. Your inquiries are invited.

NEW YORK TRANSFORMER COMPANY
26·28 WAVERLY PLACE, NEW YORK, N.Y.

center of hole. A slight rocking motion is required to locate contacts at right angles to walls of hole in all positions except at bottom of hole. Gage measures diameter direct and can be easily set to a master, gage blocks or a micrometer. Indicator is "Model C1KS," graduated 0.0001″; range of contact points −0.005″ to + 0.003″; dial 0.0015″–0–0.0015″. Range of "P-20" is 0.500″ to 0.750″ with 5 extensions; range of "P-21" is 0.750″ to 1.250″ with 8 extensions.—*Federal Products Corp., 1144 Eddy St., Providence, R. I.*

Electric Tachometer

New self-energized tachometer can be used either as a "Hand Type" or "Separable Type." Essentially, it consists of a small generator coupled electrically to an electric instrument. Generator itself consists of a small Alnico permanent magnet rotor mounted on precision sealed ball bearings and capable of continuous operation at any speed within limit of indicator. This indicating instrument is a rectifier type, with d'Arsonval movement, capable of withstanding a momentary overload up to four times the maximum speed indication without damage. It is provided with two scales—"Hi" and "Lo." The "Hi" scale indicates the maximum reading obtainable. A small switch incorporated in the case provides for easy changing from "Hi" to "Lo" range. Generator and indicator are made as distinctly separate elements; may be coupled together by a precision made bayonet lock as a "hand type" tachometer or, for many applications including permanent mounting, generator and indicator may be separated and connected only by a two-conductor electric cord. A 5-ft. cord complete with coupling plug is provided, but a cord up to several hundred feet long (of proper size wire) can be used without introducing appreciable error in scale reading. Size of generator 1⅝″ dia. × 3¾″ long, (including ¾″ shaft extension); weight 8 oz. Size of indicator 3″ × 4¼″ × 2½″; weight 20 oz. Size of complete unit, 3″ × 7½″ × 2½″ (including ¾″ shaft extension), weight 3 lbs. New tachometer is available in two sizes for 0 to 2500 r.p.m. and 0 to 5,000 r.p.m.—*Ideal Commutator Dresser Co., 1420 Park Ave., Sycamore, Ill.*

Signalling Timer

New "Series S Signalling Timer" is designed to command visual and audible attention the instant a time interval is completed, it provides for automatic closing or opening of a circuit at end of elapsed time, operates additional buzzers, bells or lights at remote locations. *Operation:* When pointer is manually set to required interval

FEDERAL
DIAL INDICATORS and GAGES

"If you haven't used one of these gages, you don't know their possibilities."

CALIPER GAGE—a very popular gage with hundreds of practical, everyday applications.

SNAP GAGE (adjustable)—no dependence on "feel". Dial tells at a glance the whole story.

HOLE GAGE — entirely mechanical, easy to use, self centering, sensitive and accurate.

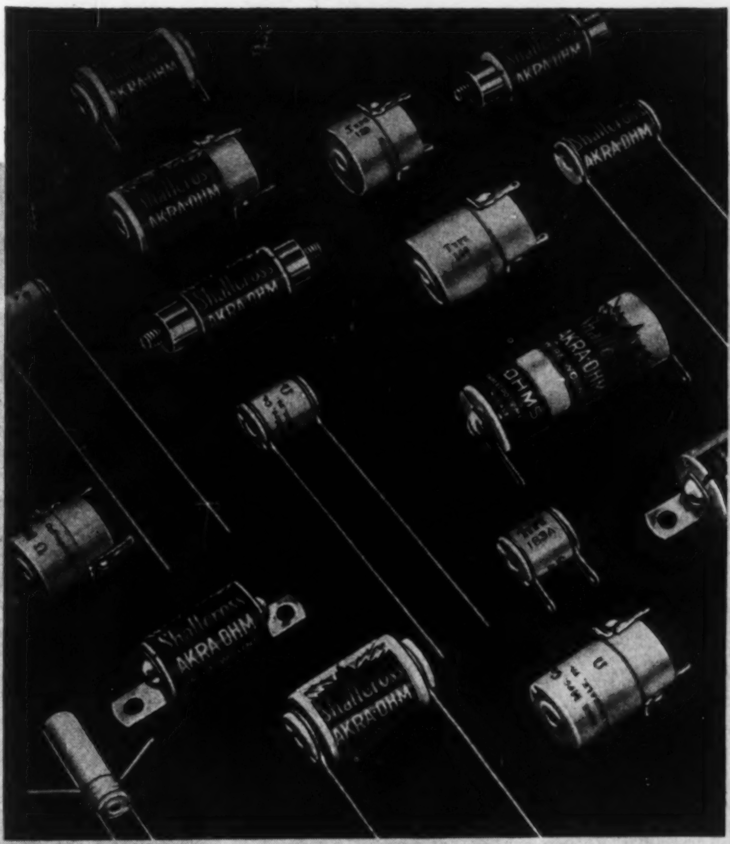
THREAD GAGE—measures pitch diameter quickly and accurately. Contacts easily changed for various pitches.

TESTMASTER Universal DIAL INDICATOR —small, accurate, compact and light. For general tool room and machine shop use.

hese and hundreds of other Federal gages, daptable to practically any gaging requirement, ill help you accurately control dimensions in roduction and make possible fast, dependable nal inspections. For further information, write

EDERAL PRODUCTS CORP.
ROVIDENCE 1, RHODE ISLAND

nd now we've added he "White Star" to ur flag.



SPECIALISTS
IN CLOSE-TOLERANCE RESISTORS

Close-tolerance resistors are the kind that Shallcross makes.

We were first to produce non-inductive pi-wound resistors.

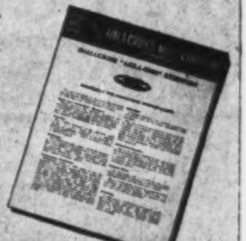
We make a broader variety of types to a standard tolerance of 1% than any other manufacturer.

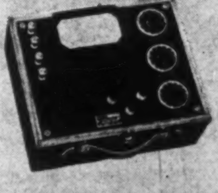
These include all ranges from a fraction of an ohm to 10 megohms, in many shapes and sizes.

Other types as exact as 0.05 of 1% are also available.

Every Shallcross AKRA-OHM Resistor is moisture-protected, fully dependable, and time-tested on exacting applications throughout the world.

It pays to buy exacting items from a specialist. Our engineers will gladly cooperate in helping you select the proper type. Write for the Shallcross Akra-Ohm Resistor Catalog.





SHALLCROSS INSTRUMENTS

SHALLCROSS BOND TESTERS

SHALLCROSS PRECISION SWITCHES

SHALLCROSS MFG. CO.
ENGINEERING · DESIGNING · MANUFACTURING
Collingdale, Pa. Dept. IS-14

Behind the Scene of Action

The PALMER Thermometer works silently, without glamour, because it was built for long service, guaranteed accuracy and to be easy to read.

When battles are fought above deck, the engineers continue their scheduled tasks, obeying orders side by side with high powered Diesel Engines and the Thermometers and instruments upon which they rely.

When Victory comes again, give the Instruments and the Men equal credit for a job well done. In Peace Time, these same Thermometers will give you . . .

LONG LASTING SERVICE
GUARANTEED ACCURACY
RED - READING - MERCURY
(So Easy to Read)

THE PALMER COMPANY, Mfrs.
INDUSTRIAL, LABORATORY, DIAL & RECORDING THERMOMETERS
2511 Norwood Ave., Cincinnati, Norwood, O.—Canadian Plant: King & George Sts., Toronto

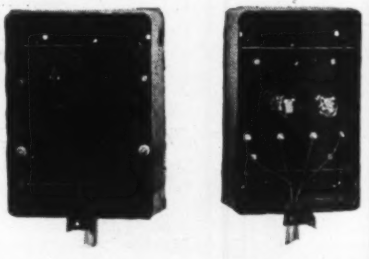
shown on dial, a circuit is closed which operates a pilot light indicating that the time interval has started. Moving pointer revolves counter-clockwise toward zero and shows time elapsed. When interval is completed, audible alarm sounds and pilot light goes out. Buzzer continues to sound until toggle switch is snapped to "off" or the timing interval is again started by moving pointer to the required time interval. Socket on side of timer case provides for connection of additional lights or alarms. If circuit closure is required during the time interval, change-over wire and terminal is provided at rear of timer case. Rapid resetting of pointer knob, when the same time interval is to be repeated indefinitely, is afforded by adjustable stop. Black metal case is readily attachable to any wall or panel or standard switch box. Size 5" × 5" × 3½" deep. Operates on a.c. 115 to 230 volts: 25, 50 or 60 cycles, 1000 W. Voltage and frequency to be specified. Motor is slow-speed self-starting synchronous type. Pure silver contacts are used throughout. Connection to the line is made with line cord. Voltage, frequency and switch rating are plainly indicated on name plate. Models are available with dials to: 1, 3, 5, 10, 15 and 30 min., 1 and 3 hr.—*Industrial Timer Corp., 117 Edison Pl., Newark, N. J.*

Magnetometer for Aircraft Analysis

New "Model MW-3" Aircraft Magnetometer is primarily designed for magnetic control of the air frame, but is also useful as a general-purpose precision instrument for magnetic measurements. Components of the earth's field can be accurately measured at the test site. In aircraft, it may be placed at the compass location or a proposed compass location and used to measure direction and magnitude of magnetic fields present. Magnetized members or electric circuits producing magnetic fields can be readily located and magnitude and polarity of the distortion measured. It can also be used as a general-purpose instrument and for mapping magnetic fields surrounding equipment. Magnetometer comprises: (*a*) Indicating Unit consisting of a stabilized, low-gain amplifier and an electronic bridge for indicating field strength and polarity; (*b*) Pick-up Unit which supplies controlling signal to indicating unit and is mounted for rotating about a vertical axis to determine angles accurately. Summary of other features: "Reversibility of flux gate, 180° apart, adjustable; accurate protractor scale—read to 3′ of arc; calibration in degrees variation of scale reading; non-shifting zero; peep sights for alignment; sensitive level tubes; direct reading scale—no calibration chart; multiplier scale in convenient units; easy to calibrate; sensitivity 10 or less milligausses full-scale; no interference between pick-up and indicating unit—at 3′; temperature effects, if any, can be nullified by means of quick calibration check."—*Waugh Laboratories, 420 Lexington Ave., New York City.*

Bin Level Indicator

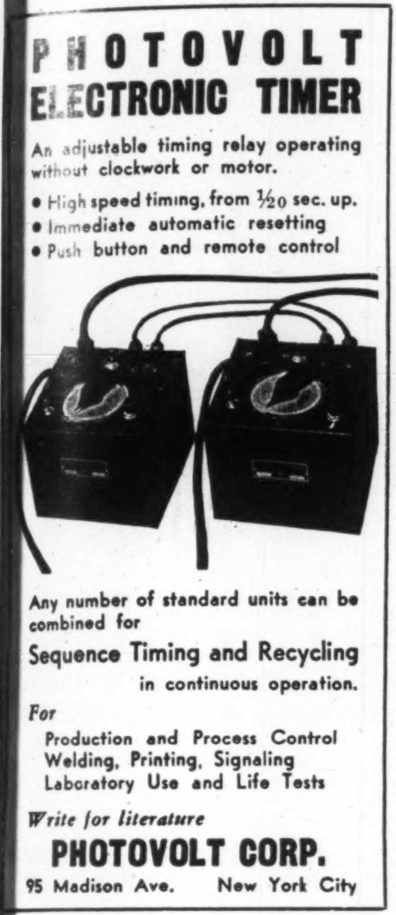
New dry materials bin level indicator utilizes electronic principle, is said to be "wholly foolproof because there are no moving parts to wear or get out of order," is effective in measuring all types of material, whether fine or coarse, is said to be easy to install and inexpensive. System consists of two parts: (1) A detector box attached to a probe extending into the bin, and in which box are a series of vacuum tubes. (2) Signal control which is attached to a series of colored lights that show when the bin is full, empty, etc. Hook-up with valve cut-offs, sound makers, or remote signal devices can readily be arranged through a series of appropriate relays.—*Mosher Electronic Control Systems, 130 West 42nd St., New York 18, N. Y.*



Good News!

Reprints of Spencer's serial on Maintenance and Servicing of Electrical Instruments are available.

See page 80



PHOTOVOLT ELECTRONIC TIMER

An adjustable timing relay operating without clockwork or motor.

- High speed timing, from 1/20 sec. up.
- Immediate automatic resetting
- Push button and remote control

Any number of standard units can be combined for

Sequence Timing and Recycling

in continuous operation.

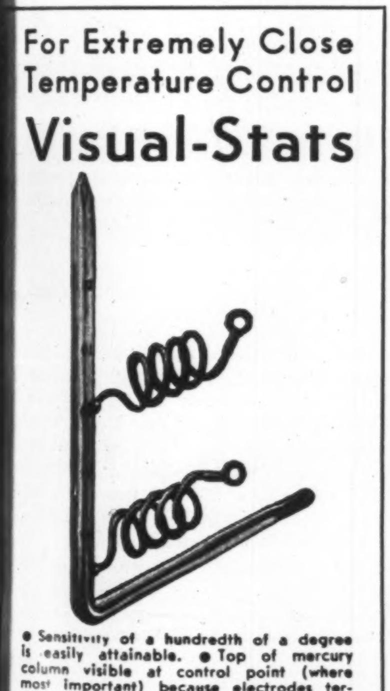
For

Production and Process Control
Welding, Printing, Signaling
Laboratory Use and Life Tests

Write for literature

PHOTOVOLT CORP.

95 Madison Ave. New York City



For Extremely Close Temperature Control

Visual-Stats

- Sensitivity of a hundredth of a degree is easily attainable. • Top of mercury column visible at control point (where most important) because electrodes terminate at back of tube. No encircling metal bands! • Available in angle form (illustrated) or conventional straight form.
- Send for brief, attractive bulletin.

The Philadelphia Thermometer Co.

915 Filbert Street -:- Philadelphia

Oldest Thermometer Manufacturer in Philadelphia

Matched

MIDGET CONTROLS

WIRE WOUND 1 to 10,000 ohms

COMPOSITION ELEMENT 500 ohms to 5 megohms

New

Clarostat Type 43

WIRE-WOUND MIDGET

Smallest unit now available of that rating.

• • •

Rated at 2 watts. 1 to 10,000 ohms.

• • •

Matches Clarostat Type 37 midget composition-element control—in appearance, dimensions, rotation, switch.

• • •

Available with or without power switch.

• • •

Available in tandem assemblies—suitable combinations of wire-wound and composition-element controls.

• • •

Type 37 composition-element controls rated at 1 watt. 500 ohms to 5 megohms.

★ They look, measure and operate the same—these Clarostat wire-wound and composition-element midget controls. Fully interchangeable, mechanically. Can be made up in various tandem assemblies.

Clarostat Type 37 midget *composition-element* controls have been available for several years past. Their *stabilized* element has established new standards for accurate resistance values, exceptional immunity to humidity and other climatic conditions, and long trouble-proof service.

And now the Clarostat Type 43 midget *wire-wound* control is also available, to match Type 37—matched in appearance, dimensions, rotation, switch.

For neatness, compactness, convenience, trouble-free operation—just specify these Clarostat *matched midget controls.*

★ *Write for literature. Submit that resistance or control problem. Let us quote on your requirements.*

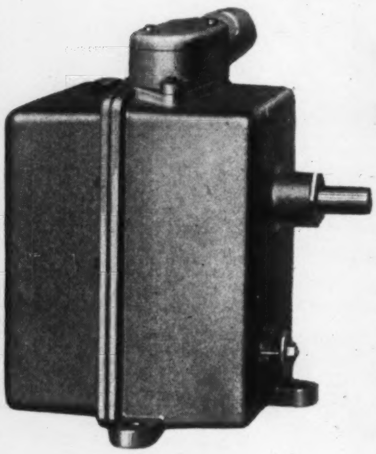
CLAROSTAT

Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

BARBER-COLMAN

HEAVY DUTY POWER UNIT



This sizeable (11" x 10⅜" x 9½" overall) power unit, which operates off line voltage, is ideal for applications requiring a heavy-duty high-torque (350 to 750 lb. in.) motor and gear reduction with built-in limit switches. Common uses include: • Regulation of heavy dampers in combustion control systems. • Operation of large butterfly valves and blast gates. • Operation of large air and gas valves, multiple ratio fuel valves, and industrial fuel carburetors. ★ Write for Bulletin F-1912 "Power Units".

TYPE "AYCK"

MAXIMUM SERVICE Controls by BARBER-COLMAN COMPANY MINIMUM MAINTENANCE

BARBER-COLMAN COMPANY
1202 ROCK ST. • ROCKFORD, ILL.

Want Complete Blackout and Fully Illuminated Jewel?

NEW efficiency has been designed and built into the new No. 85 DRAKE Shutter Type Assembly! Now, for the first time, a 90 degree clockwise turn made easy by a sure-grip knurl, brings COMPLETE blackout . . . a 90 degree counter clockwise turn FULLY illuminates jewel. (Same rotation as aircorps part #42B3593). This new No. 85 is, we believe, the ONLY Shutter Type Assembly without a central pilot hole that permits light leakage. A firmly locking, slip-fit bezel is instantly removable without tools, for easy lamp replacement. It has the same general specifications and is interchangeable with our No. 80 Polaroid Type Assembly. Do you have the newest Drake Catalog describing the No. 85 and other new Drake patented products?

DRAKE MFG. CO. CHICAGO
PAT. NO. 2220516

DRAKE

NO. 85 SHUTTER TYPE
PILOT LIGHT ASSEMBLIES

DRAKE MANUFACTURING CO.
1713 WEST HUBBARD ST., CHICAGO 22, U.S.A.

The Paper Conservatio Campaign

A statement by
Richard Rimbach, President,
The Instruments Publishing Co.

DONALD M. NELSON, Chairm of the War Production Board, a recent letter to magazine publishe states:

> "The shortage of pulpwood and wo pulp has become more serious, and it necessary for us to place additional strictions on your use of paper, beginni January 1. Similar curtailment will al be required of other paper users, in ord that the sacrifice will be distributed equ tably.
>
> "It will tax your resourcefulness to me the additional cut, and the contributio your periodicals are making to the w effort will be hampered in some degre However, with the same recognition th you accorded to the need for the earli reduction, I am sure your record suppor my belief that you will do the job th must be done."

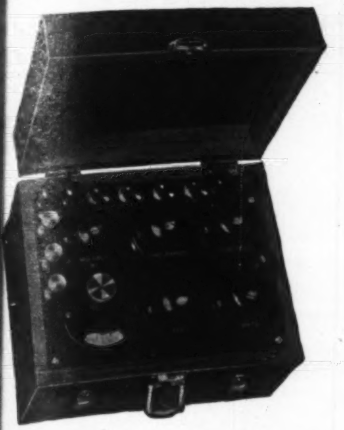
A number of suggestions are offer by the WPB in order to "stretch t paper mileage." Publishers are urg to "study these items and discuss the with the printer."

Reduced Basis Weights: It is pointe out that pre-Pearl Harbor magazine used up to 80-pound basis weights wi covers up to 150-pound basis. *Instr ments* and *The Instrument Maker* hav reduced basis weights in line with othe magazines. At present these publica tions use 30-pound machine-finished f editorial-matter pages, 40-pound coate for advertising and 70-pound coate for covers.

Reduced Overall Trim Size: Befor the War most trade and technic magazines used an overall trim size 8¾" × 11¾". In January 1943, thi was reduced to 8⅛" × 11¼". Thi January the size is being reduced t 8" × 11⅛". Our two publications ar conforming to this size.

Reduced Type Size and Leading WPB suggested that type sizes be r duced: for example from 12-point o 14-point body to 10-point on 11-poi body, thereby requiring less paper fo a given amount of editorial content. I 1938 the editor of *Instruments* made study of the comparative legibility an words-per-square-inch characteristi of all the body type faces available our printers' and, as a result, the ty for feature articles in *Instruments* w changed beginning January 1939 to on-9 "Century"—giving approximate 42% more words per square inch tha before this change. For the depar ments of *Instruments* which had be set in 8-on-9, he specified 6-on-7 (a in some cases 6-on-6) Century. Som what similar changes were subsequen ly made in *The Instrument Make* Examination of these two publicatio will show that further reduction

PORTABLE
HEATSTONE BRIDGE



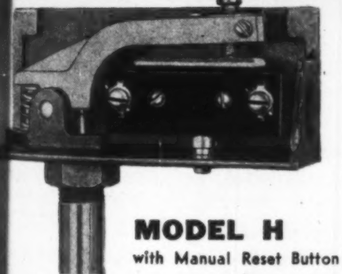
igh grade instrument for measuring re- nces from a fraction of an ohm to 10 ohms. Contains a 4-dial rheostat, ratio galvanometer and battery, all enclosed substantial walnut case. Nine coils per Accuracy .1%. Built to endure.

No. 1050—Portable Wheatstone Bridge with Murray and Varley Loops...$110.00
No. 1052—Portable Wheatstone Bridge without Murray and Varley Loops.$90.00

Send for Bulletin No. 105

UBICON COMPANY
Electrical Instrument Makers
ge Ave. at 35th St. Philadelphia, Pa.

BURLING
TEMPERATURE
LIMIT SWITCHES



MODEL H
with Manual Reset Button

ilable with switch normally closed for ing off heat, stopping fan, closing valve ith switch normally open for lighting or ringing bell—with single pole ble throw switch . . . breaks heating circuit e closing alarm circuit. Sturdy, fool-proof button operates from outside case. Range 00° F; adjustable range 200-300° F. Di- sions: 5⅛" x 1¾" x 3". Dial Pointer for setting.

RUMENTS ALSO BUILT TO SPECIFICATIONS
Send for Informative Bulletin

URLING INSTRUMENT CO.
251C Springfield Ave.
Newark. N. J.

"... a SIMPLE mechanism, using a photocell ...."

Popular magazine articles, speaking of the wonders of modern instruments, often imply that anything with a photocell is complicated. Actually, Luxtron* Photocells simplify the circuits and operation of equipment. For instance:

LEITZ PHOTO-ELECTRIC COLORIMETER

speeds, simplifies, and gives new accuracy to a multitude of bio-chemical tests.

Each instrument is individually precalibrated for 36 different tests. A revolving filter disk is permanently installed, simplifying filter changes. Light intensity can be varied by operating a unique "light valve." All you do to complete a test with the Leitz Photo-Electric Colorimeter is: 1. With a cell containing distilled water inserted, set the indicator at 100. 2. Replace the distilled water cell with one containing the unknown, then note the new reading. 3. Refer the new reading to the instrument's calibration table for the exact concentration of unknown.

For further information on this useful instrument, write direct to E. Leitz, Inc., 730 Fifth Avenue, New York 19, N. Y.

The Leitz Photo-Electric Colorimeter uses a Luxtron* photocell, of which Leitz literature says: ". . . possesses exceptionally stable and uniform characteristics. Its high sensitivity in the range of short wave lengths of the spectrum is a definite advantage in many colorimetric determinations . . ."
Luxtron* photocells develop sufficient current for direct operation of instruments and sensitive relays without requiring amplifiers.
For complete technical data on Luxtron* photocells, write Bradley.

**Trade mark Reg. U.S. Pat. Off.*

BRADLEY
LABORATORIES, INC.
82 Meadow Street, New Haven 10, Conn.

Miniature-type
VIBRATING REED
FREQUENCY METERS

FR
MODEL 7007 FREQUENCY METER
57 59 61 63
58 60 62
CYCLES PER SECOND
125 VOLTS
48 50 52
58 60 62
59 61 63
60 62

PROMPT DELIVERIES!

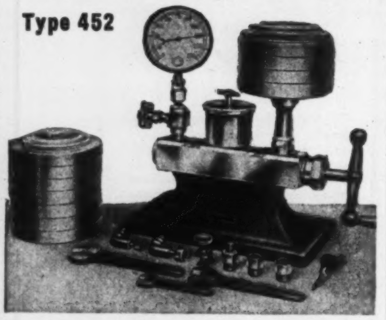
Three stock models—5, 7 and 10 reed...available in wide range of frequencies and all standard line voltages; operates correctly in any position. No pivots, jewels, or rotating parts . . . simple construction assures exceptional accuracy. Built to highest Government standards.

WIRSHING MANUFACTURING COMPANY
3234 Mines Avenue • Los Angeles 23, California

Write for complete catalog data and Quantity Prices, and learn the exceptionally favorable delivery available

AMTHOR Dead Weight Pressure Gauge TESTER

Type 452



Modern design and construction puts this rugged precision instrument in a grade above the ordinary dead-weight testers.

Made in eight ranges, to 3000 lbs. maximum.

We guarantee 1/10 of 1 percent accuracy in each range.

The Type 452 is designed for simplicity and compactness. It incorporates the newest refinements and improvements. Adapters and tools are supplied, as well as either carrying case or protecting cover.

Immediate and intelligent attention will be given to your inquiries on all industrial speed measurement problems. Drop us a line today.

Amthor Testing Instrument Co., Inc.
49a Van Sinderen Ave. Brooklyn, N. Y.

Bausch & Lomb Oil Immersion Objective—97X-N.A. 1.25.

Accuracy that Counts on all Fronts

At first glance there would seem to be little relationship between an intricate, ten-foot long height finder and a microscope objective with lenses of less than one millimeter in radius. Yet both are the products of the same eyes, the same facilities, the same standards of accuracy, the same experience. Both are aiding in America's war effort. Both are products of Bausch & Lomb.

The lens computing and grinding skills that for years have produced the minute, exceedingly accurate lens components of the microscope objective are today also being employed in the production of height-finders and gunfire control instruments that are helping America's armed forces to win an earlier Victory.

Because of its wartime accomplishments, Bausch & Lomb will be able to extend its optical services to peacetime pursuits when Victory is won.

For Bausch & Lomb Instruments essential to Victory—priorities govern delivery schedules.

BAUSCH & LOMB
OPTICAL CO. • ROCHESTER, N. Y.
Established 1853

their type sizes would defeat its pu pose: the matter so printed, howev informative and valuable to the W Effort, would not all be read by har working subscribers.

Smaller Margins, etc.: WPB su gested that smaller margins be us on pages, that space between colum be reduced and that space around cu also be reduced. In January 1939 th editor of *Instruments* reduced the spa between columns from 2 picas to 1 pic and of course reduced space aroun cuts to harmonize. Now the reductio in magazine trim size reduces margin A glance will show that the practic limit has been attained. The same ap plies to *The Instrument Maker.*

Reduced White Area: It is suggeste that "frills and luxury of white spac around illustrations, headings and cap tions" be eliminated. Neither *Instru ments* nor *The Instrument Maker* ha ever indulged in such frills, so that n worth-while savings could be accom plished without making the averag page look like a page in a dictionar Since even before the invention o printing, when books were lettered b hand, it has been known that SOM white space is necessary to preven eye-strain, to invite attention to head lines and sub-titles, etc.

Elimination of Bleed Pages:

"Bleed pages normally use larger overa sheet sizes. Elimination of bleed pages wi in many cases relieve the publisher fro carrying duplicate inventory of bleed an non-bleed sheet sizes and permit the pub lisher to use the smaller size sheet. Ap proximately 5% gain can be made in pape usage through elimination of bleed pages

The elimination of bleed pages is decision which must be made by th advertisers and we hope that they wi go along with the WPB suggestion.

Reduced Width of Chase Bars: This matter was discussed with our printe and we are told that it would be necessary to get new chases, which cannot be done at present due to other limitation orders.

Press and Bindery Waste: This i the printer's problem and has always been called to the attention of our printer as any waste here represents an increased cost to us.

Reduced Spread Between Print Orde and Net Distribution:

"Hold to a minimum the spread betwee gross print order and net distribution. Re duce the number of promotion, complimentary, advertisers, advertising agency and employee copies. In addition, eliminate o reduce the printing of extra copies held t give back copies to new subscribers, or t answer requests for additional copies o particular articles or advertisements. Re check your mailing lists to see whether un necessary copies are being sent, or whethe subscriptions are being carried beyond ex piration dates."

For almost two years, we have totall eliminated promotion and compliment ary copies. The number of copies pe advertiser has been reduced to neces sary checking copies. Foreign circula

TRERICE

THERMOMETERS

No. A12402½ Industrial

No. M81110 Dial

No. M82115 Recording

TEMPERATURE CONTROLLERS

No. 90000 Self-Operating

No. V85002 Air-Operated Non-Indicating Type

No. M87000 Air-Operated Recording

PRESSURE GAUGES

No. 800 Steel Case

No. 600 Iron Case

No. 730 Hydraulic

Write for Catalog 101-G

H. O. TRERICE CO.

Manufacturers of Temperature Instruments
1420 W. LAFAYETTE BLVD.
DETROIT 16, MICHIGAN

AIRCRAFT
THERMOCOUPLES

Gasket or Blind Rivet Type Thermocouples

Calibrated Lead Wires

Firewall Connectors

Army, Navy and Commercial Types

THE WINSLOW COMPANY
INCORPORATED
9 Liberty Street, Newark, N. J.

INTEGRITY OF DESIGN

. . . a phrase that tells the story of a business

The phrase, *Integrity of Design,* has come to typify that "lengthened shadow" behind the business of creating Jackson Instruments. Like Topsy, it "just growed" into our thinking and into our work. Today it constitutes our inspiration—and our constant challenge, permeating every phase of anything we do.

The very *naturalness* of this phrase, as applied to Jackson Instruments, has kept forcing itself forward—until *Integrity of Design* has become the hallmark of Jackson Instruments. It represents that unseen *plus* that comes from "hidden" care. It means that Jackson products are conceived, designed, developed and built—not for low price—but for *high performance.*

And that is why on all fronts Jackson Instruments are measuring up to the demanding tests of war. It is why, too, in the peacetime "tomorrow" to come they will emerge better than ever—from having had to meet the tests of today's raging world conflict.

Let's keep shooting all we can into War Bonds. There's nothing more vital that we on the home front can do.

JACKSON

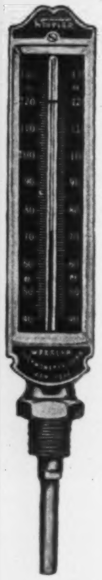
Fine Electrical Testing Instruments

JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO

WEKSLER

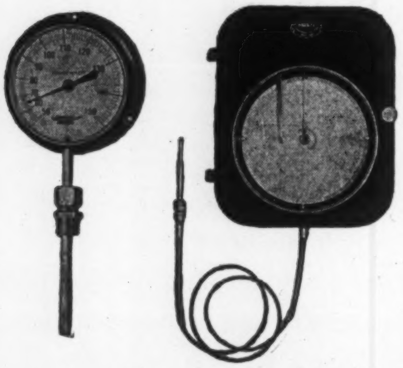
Production or Research Instruments

Weksler Thermometers are scientific, precision instruments. Their rugged construction and lasting accuracy will merit your full confidence. Red Reading and Yellow back Mercury tubes are standard in all V shape industrial thermometers. Indicating and recording thermometers are furnished mercury, vapor, or gas actuated. Dial indicating instruments are available in 4½", 6", and 8½" phenol condensate cases, and recording thermometers in 10" chart size. There is a Weksler precision thermometer for every industrial need.

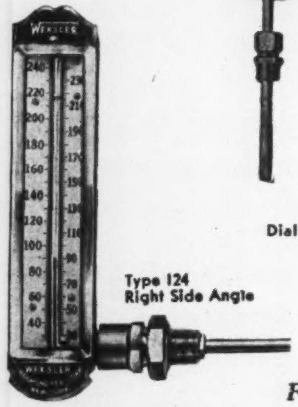


"V" Shaped Bronze Case Industrial

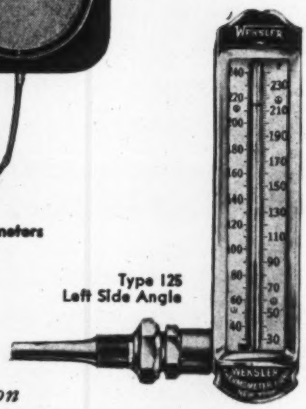
Thermometers and Hydrometers



Dial and Recording Thermometers



Type 124
Right Side Angle



Type 125
Left Side Angle

For information on

Dial and Recording Thermometers, send for Catalog 300 DR
For others, send for Catalog No. 115.

Weksler Thermometer Corporation
52-56 WEST HOUSTON STREET, NEW YORK, N. Y.

tion has been eliminated for the duration.

Subscribers can materially help in this connection by sending us their renewal subscriptions as soon as they receive an expiration notice. The woman-hours in our Circulation Department also would be materially reduced by 50% if subscribers would send us a two-year renewal for $3.00, rather than a one-year renewal for $2.00.

Beginning in January the Government is starting a paper conservation campaign. Ads will appear in newspapers, magazines, etc. Read them and do your share.

—R. R.

Just Out!
WRITE FOR YOUR COPY TODAY
NEW SpeedWay

MOTOR CATALOG

Shows description, gives dimensions and output of small motors from 1/3000 h.p. to 1/3 h.p. plain and back-geared motors, for A.C., D.C., or Universal operation—dependable, efficient and economical SpeedWay Motors embodying the "know how" developed through more than 30 years of specialization in small motors — the "know how" that has answered so many war problems, for all branches of the service.

If you use small motors, write for this new catalog today. If you have small motor problems, send in your specifications for SpeedWay's recommendations.

SPEEDWAY MANUFACTURING CO., 1870 S. 52nd Ave., CICERO, ILLINOIS

Instrument DIALS AND SCALES
ETCHED OR LITHOGRAPHED IN ALL FINISHES

OUR 30 YEARS EXPERIENCE
ASSURES BEST QUALITY
& PROMPT PERFORMANCE.

NAMEPLATES • PANELS *etc.*
AND ON ANY METAL

PREMIER METAL ETCHING COMPANY
21-03 44TH AVENUE LONG ISLAND CITY, N. Y.

Simple as A-B-C

● WITH this Trimount fully enclosed sliding scale U tube manometer, you set the pointer to the low liquid level in one leg, read DIRECT from level in other leg. Fool-proof, error-proof, fast! Just one of many outstanding Trimount instruments designed for fast, accurate pressure readings.

SEND FOR CATALOG

Trimount Instrument Co.
523 SOUTH PLYMOUTH CT.
CHICAGO, ILL.

Detection

You DON'T HAVE TO SNEAK UP ON A **VIBRATION!**

The **HATHAWAY**

Oscillograph will record vibrations of any characteristics for you, permanently, for your information when you need the facts.

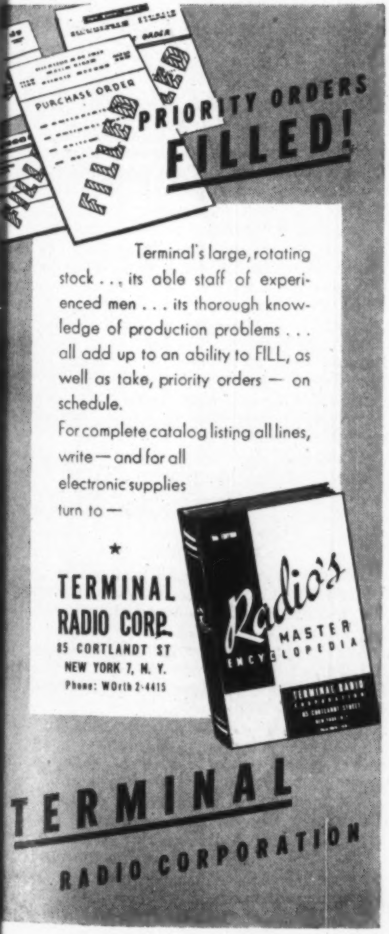
The new type S-8 is ready with 6, 12, or 24 elements. Charts six to ten inches wide up to 200 feet long can be made. You can remove and develop any length anytime. Galvanometers are available for use in this S-8 Oscillograph having a wide range of sensitivities.

Governor-controlled motor • Simultaneous viewing screen
Automatic numbering device • True craftsmanship and finish

WRITE FOR DETAILED STUDY AND COSTS:

Hathaway Instrument Co., 1315 South Clarkson St., Denver 10, Colorado

Hathaway INSTRUMENTS



PRIORITY ORDERS FILLED!

Terminal's large, rotating stock . . . its able staff of experienced men . . . its thorough knowledge of production problems . . . all add up to an ability to FILL, as well as take, priority orders — on schedule.

For complete catalog listing all lines, write — and for all electronic supplies turn to —

★

TERMINAL RADIO CORP.
85 CORTLANDT ST
NEW YORK 7, N. Y.
Phone: WOrth 2-4415

TERMINAL
RADIO CORPORATION

USED BY AMERICA'S LEADING MANUFACTURERS

TRU-VAC
VACUUM GAUGES
(Pirani Type)

Shown at right is meter box of our No. 6 gauge giving accurate, dependable service in all types of operations
ORDERS ACCEPTED FOR EARLY DELIVERY

CONTINENTAL ELECTRIC COMPANY
CHICAGO OFFICE 903 MERCHANDISE MART
GENEVA, ILL.
NEW YORK OFFICE 265 W. 14th ST.

INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control	J. E. Eaton, 425 Peachtree St. N.E., Atlanta				
Baltimore	Baltimore Industrial Instrumentation Society	C. B. Willnecker, 6732 Danville Ave., Dundalk, Md.	**Jan. 21(D)**	Maryland Academy of Sciences	The Pneumatic Null Balance System	C. B. Moore, Moore Products Co.
			Feb. 18	Dinner meeting. See details in report on this page.		
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago	**Feb. 7(B)**	Huyler's Restaurant, 308 S. Michigan Ave.	Liquid Level Control	Dr. D. J. Bergman, Universal Oil Co.
			Mar. 6	**To be announced**	Furnaces with Controlled Atmospheres	N. K. Koebel, Lindberg Eng. Co.
Gulf Coast	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Tex.	**Feb. 9**	Lamar College, Beaumont, Tex.	To be announced	Charles Smoot, Republic Flow Meters Co.
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.				
Newark	New Jersey Society for Measurement & Control	N. E. Chance, 14 Glen Oakes Ave., Summit, N. J.	**Feb. 1(B)**	Essex House, Newark, N. J.	Metallurgy As It Affects Instruments	Dr. N. E. Woldman
New York	New York Society for Measurement & Control	R. K. Farnham, 545 Fifth Ave., N. Y. C.	**Jan. 25(B)**	Building Trades Emp. Ass'n, 2 Park Ave.	Airplane Stability and Automatic Flight	Dr. S. J. Zand, Sperry Gyroscope Co.
			Feb. 29(B)	Building Trades Emp. Ass'n, 2 Park Ave.	To be announced	Dr. R. M. Sutton, Haverford College
N. Indiana	Northern Indiana Soc. Measurement & Control	R. W. Schreiner, 4 Waltham St. Calumet City, Illinois	**Feb. 19(B)**	**To be announced**	Oil Refinery Instrumentation	O. G. Kassa, Sinclair Ref. Co.
			Mar. 10	**To be announced**	Dev. of Perm. Magnet and Applications	C. A. Maynard, Indiana Steel Products Co.
Philadelphia	Philadelphia Society for Instrumentation	George Hammer, 712 Otis Bldg., Phila. Pa.	**Jan. 19(B)**	Engineers Club	Measurement of pH and Conductivity	Dr. W. N. Greer, Leeds & Northrup Co.
			Feb. 16(B)	Engineers Club	To be announced	To be announced
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.	**Jan. 24(B)**	Roosevelt Hotel	Graphical Method of Process Analysis	J. G. Ziegler, Taylor Instrument Co's
			Feb. 28(B)	Roosevelt Hotel	Automatic Temperature Control	C. O. Fairchild, C. J. Tagliabue Mfg. Co.
			Mar. 27(B)	Roosevelt Hotel	Principles of Automatic Temperature Control	J. C. Peters, Leeds & Northrup Co.
St. Louis	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co.				
Toronto	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co., Toronto				

(A)Meeting at 7:30, no dinner. (B)Dinner at 6:30, meeting at 8. (C)Dinner at 7, meeting at 8. (D)Meeting at 8, no dinner.

BALTIMORE

The December 17, 1943 meeting of the Baltimore Industrial Instrumentation Society was held at 8:00 p.m. at the Maryland Academy of Sciences, 2724 North Charles Street.

The scheduled speaker, Mr. H. L. Pfaffhausen, Leeds Northrup Co., was unable to attend due to illness. Vice President Byron Dewey conducted the meeting in the absence of our President Forrest Bevelheimer. A dinner meeting for February 18, 1943 was announced and tickets at $2.25 each went on sale immediately. Anyone interested in attending this dinner meeting may get their tickets by contacting the Secretary.

—Carl B. Willnecker, *Secretary.*

CHICAGO

The December 6 meeting of the Chicago Society for Measurement & Control, was held at Phil Smidt's restaurant, Roby, Indiana. A large crowd was on hand to hear the speaker of the evening, Mr. V. H. Hiermeier of the Brown Instrument Co., talk on "Instrument Maintenance in an Oil Refinery."

Mr. Hiermeier devoted his entire paper to the subject of the personnel of instrument maintenance in an oil refinery. He stressed the necessity of educating and grading the instrument men in such a department. His remarks were enjoyed by all but particularly by the heads of many of the plant instrument departments.

The Chicago Society is enjoying an exceptional increase in its membership, which increase is very gratifying to all of the officers.

—J. A. Riggs.

NEWARK

In spite of the most inclement weather and icy highways there was an attendance of forty-one members at the January 4 meeting of the Society for Measurement and Control, at the Essex House, Newark, N. J.

Mr. Wm. E. Englehart, of Pyrometer Service Company, spoke on "Pyrometer Maintenance in Industrial Plants. His talk was not only highly instructive but struck a most responsive chord in these times of manpower shortage and difficulties in securing materials.

Mr. Englehart covered particularly Pyrometer Maintenance of Heat-treating installations, outlining a regular procedure for care as well as specific instruction for emergency maintenance of all types of Pyrometers.

The discussions which followed clearly showed the keen interest of all members present in the practical problems of pyrometer maintenance.

—N. E. Chance, *Acting Secretary.*

NEW YORK

Nov. 30.—About seventy attended this meeting of the New York Society for Measurement and Control to hear Dr. Charles S. Draper, Professor of Aeronautical Engineering at M.I.T., talk on the "Practical Importance of Instrument Dynamics." Dr. Draper stressed the need of knowing what happens to an instrument when things are thrown at it too fast as in the case of an aircraft instrument. He opined that many future test instruments would be specified in terms of dynamics rather than statically with consequent change in design.

In a protracted discussion period Dr Draper had stimulating answers for many questions bearing on this interesting subject.

Dec. 28.—Attendance was good at our new meeting place on the 26th floor of the Park Avenue Bldg. The speaker was Charles H. Fetter, President, American Time Products, Inc., who gave an interesting talk on precision time instruments. After his talk he demonstrated the Watchmaster used to check the accuracy of timepieces in a few seconds.

Those who attended were quite favorably impressed with the facilities of our new meeting place.

Comment has come from many quarters concerning the impressive list of speakers who addressed the Society in the past year.

—Bob Farnham, *Secretary*

PHILADELPHIA

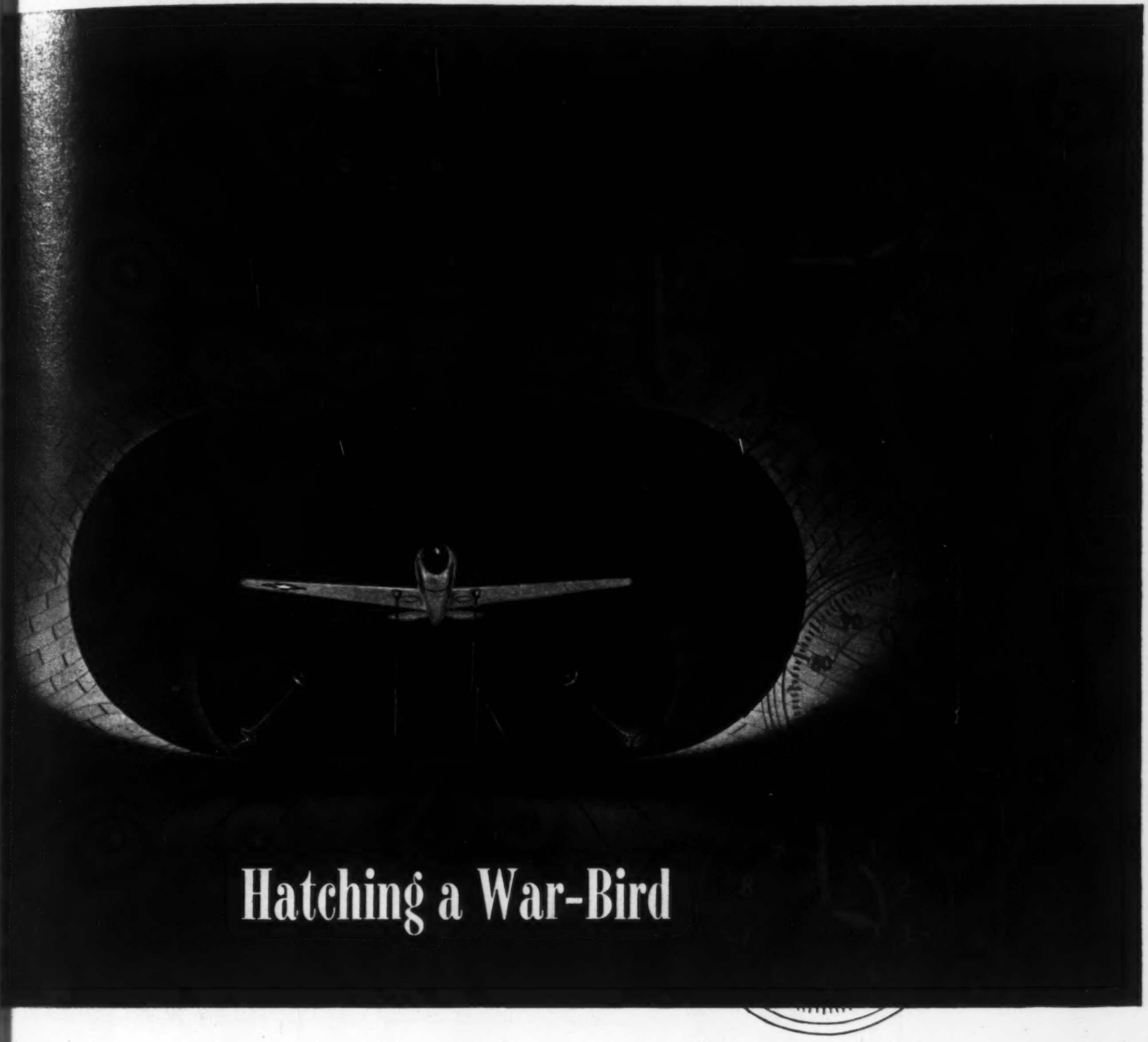
At the December 15th meeting of the Philadelphia Society for Instrumentation the following officers were elected for 1944: *President:* M. H. White, Atlantic Refining Co.; *Vice President:* T. R. Newcomb, Gulf Oil Corp.; *Secretary:* J. E. Gambrill, Moore Products Co.; *Treasurer:* C. Hannan, E. du Pont de Nemours.

Mr. Perry A. Borden, Patent Engineer The Bristol Company, was the speaker. H talk "Telemetering," with blackboard illustrations, covered the development of Remote Measurement from its earliest form up to the present day systems in use.

A right lively discussion period followed

There were fourteen at the dinner, which preceded the meeting, and 53 were present for the meeting.

—George Hammer, *Secretary*



THE majority of those who use and respect Kollsman aircraft instruments know them most intimately as sentinels on the airplane instrument panel, indispensable to the plane's precise and dependable operation.

But long before our war-birds ever get into service, many engineers certify their design and performance with Kollsman instruments in wind tunnels, engine test cells and in test flights.

Because of their accuracy, standard Kollsman instruments are found in frequent use for many forms of aeronautical experiment and in production testing. In addition, many special Kollsman instruments have been developed for these uses.

KOLLSMAN AIRCRAFT INSTRUMENTS

PRODUCT OF

SQUARE D COMPANY

ELMHURST, NEW YORK • GLENDALE, CALIFORNIA

Instrumentation in Textile Industry

Concluded from Page 35

The controller corrective actions which are most widely used are two-position, proportional, and proportional-plus-floating (automatic reset). Two-position control may utilize a wide differential, or dead zone, between the water tank level at which a pump is started, for example, and the level at which it is stopped.

When there is no appreciable dead zone we have on-off control. A sensitive on-off controller is the best choice for many applications, notably those including strong self-regulation, small resistance and supply-side capacitance, and large demand-side capacitance.

Proportional and proportional-plus-floating controls are also known as throttling controls because they hold a valve partly open. With proportional control the valve stem lift is proportional to the deviation of the controlled variable from the setting point. Thus a deviation is necessary to open the valve wider after an increase in load; and this control is subject to load error, or "drift."

Proportional - plus - floating control (automatic reset) keeps the valve slowly moving beyond its proportional position until the controlled variable reaches the setting point. This control can handle all loads without an permanent deviation.

The effect of rate-of-change of th variable is also being untilized to considerable extent. A controller includin this characteristic moves its valve ste beyond the proportional position by a amount which depends on the rate a which the variable is changing. It mo closely approaches what a human ca do with his ability to anticipate. It i needed only for the most difficult problems in automatic control.

The flow characteristic of the controlled valve is another important consideration except in the simplest control. On-off control should use a quick opening valve of any convenient siz Throttling control requires a valve t change the flow gradually as the ste rises. Its size and port design must b correct for each process.

AUXILIARY POWER

The power which energizes servo type controllers can be electricity, compressed air, water, oil or the controlle energy or medium itself.

Electricity has the advantage o availability. Its chief disadvantage lie in the power unit, which is a solenoi or a motor. Solenoid valves are limite to on-off operation while motor-operate valves suffer from high cost and th over-running effect of inertia.

The more advanced controller characteristics are less simply and economically introduced in electric control systems than in pneumatic systems. Th latter have the advantage of simplicity ruggedness, ease of understanding by mechanics, and the availability of excellent, low-cost valve power units (diaphragms or pistons). The chief disadvantage of pneumatic controllers is the necessity for a supply of clean dry air

Hydraulic controls are rugged and reliable, but relatively high in cost.

SPECIAL CONDITIONS

The engineer must always check for special conditions influencing the selection of instruments or control. Questions, such as the following, should be considered:

1. If control is to be pneumatic or hydraulic, will the air or water supply fail o be shut off at times? Is air or water suppl clean enough?

2. If the controller or its power suppl should fail, what should the action be t avoid damage or hazard in the process For example, should a controlled valve b arranged to open, or close, or stay where i is, if the controller fails?

3. If some other element of the operatio should fail, is any special response require by the controller? For example, should spee control return to a low-speed position upo stoppage of the machine?

4. Is control point to be changed frequently by the operators, or should settin be done by supervisors only?

5. How important is operation and ho reliable must controller be to avoid production tie-ups? Should emergency controls protective devices be used to back up t primary controller?

6. Will operation function for many yea or only a few months?

7. Has the maintenance personnel sufcient skill to service controllers?

8. What special provisions must be ma on account of corrosion conditions?

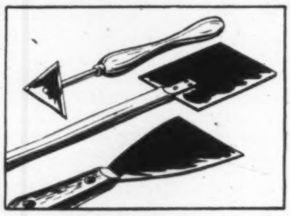
Ingenious New
Technical Methods
Presented in the hope that they will prove interesting and useful to you.

Beryllium Copper Bites Into Steel

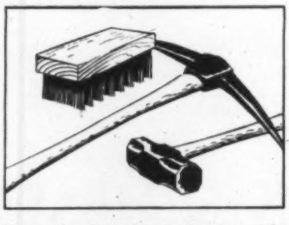
It is an old saying that when a dog bites a man it is not news, but when a man bites a dog it is news. That being the case, it is certainly news when copper bites into steel. Copper is, of course, one of the softer metals but when 2 percent beryllium is added to copper, its characteristics are changed. The alloy is heat treatable which explains the remarkable strength and hardness. Hit a chisel made of Beryllium Copper with a hammer and it will bite into steel without dulling the edge. Tools made of Beryllium Copper are non-sparking and therefore are used in ordnance plants, oil refineries and other places where explosions may occur from sparks off steel tools. Tensile strength as high as 200,000 lbs. psi can be obtained with Beryllium Copper; hence, it is used for many applications where resistance to high loading and impact fatigue are important, such as airplane motor bushings. Most of the critical springs and diaphragms used in aviation, Navy and Signal Corps instruments are made of Beryllium Copper because of its reliability as a spring material.

We hope this has proved interesting and useful to you just as Wrigley's Spearmint Gum is proving useful to millions of people working everywhere for victory.

You can get complete information about these tools from the Beryllium Corporation, Reading, Pennsylvania.



Man has tried for ages to rediscover the art of hardening copper. Today this can be done by adding to copper a small percentage of beryllium.



Not only does it produce an alloy harder than tempered steel, but one that does not produce sparks, an essential when working near highly combustible materials.

X-64

PYRO THE SIMPLIFIED OPTICAL PYROMETER

YOU CANNOT AFFORD NOT TO OWN ONE!

Because it eliminates guesswork, waste and spoilage; it pays for itself quickly. PYRO is a *self-contained, DIRECT READING, sturdy unit* made to stand rough use but it is absolutely *accurate* and *dependable.*

Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest streams; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

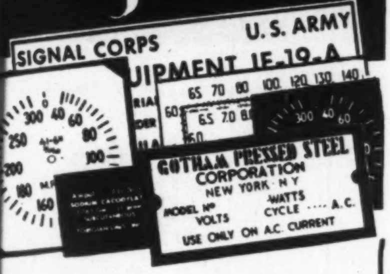
Stock ranges 1400° F. to 5000° F.

Write for Catalog No. 80

THE PYROMETER INSTRUMENT CO.
Plant & Lab.
103-107 LAFAYETTE ST., NEW YORK, N. Y.

How to Print

NAMEPLATES, DIALS, GAUGES, MARKINGS, LETTERING, TRADE-MARKS, ETC., ON ANY SURFACE



1. Facilities for complete marking production — any quantity, on any surface.
2. MULTI-MARK Screens made up for any design; reproductions may be made directly on your products without special machinery; complete directions furnished.

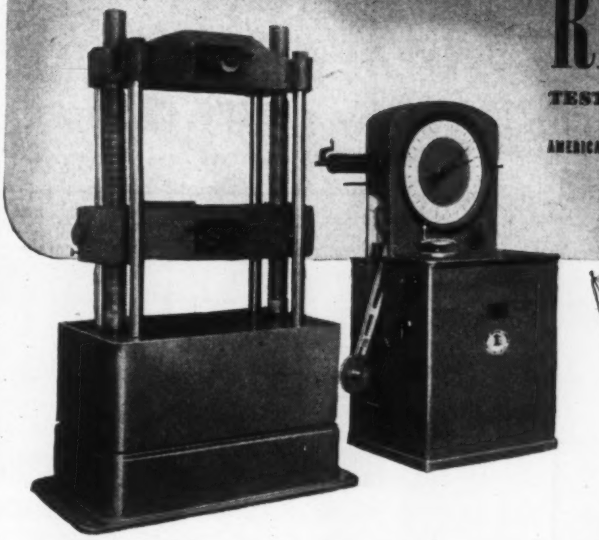
Write to us for information on marking problems . . . we've had experience with scores of them and may be able to help you.

MULTI-MARK DIVISION
Colonial Process Supply Company
136 West 23rd St., NEW YORK

PRECISION HYDRAULIC TESTING MACHINE
with Pendulum Load Indication

MORE ACCURATE, MORE DEPENDABLE FOR PRODUCTION TESTING because:

Pendulum load indicator operates on the natural laws of gravitation. . . This principle of operation is not affected by temperature changes or subject to metal fatigue. . . *Write for descriptive literature and quotations.*



RIEHLE
TESTING MACHINES
Division of
AMERICAN MACHINE AND METALS, INC.
East Moline, Illinois

ARMY E NAVY

Other Products: IMPACT TESTERS • VICKERS HARDNESS MACHINES • BRINELL HARDNESS TESTERS • MEASURING INSTRUMENTS

Test Insulation the Modern Way with a MODEL B-5 MEGOHMER

VARIOUS NEW MODELS AND RANGES

NEW BATTERY-VIBRATOR TYPE

No more tiresome cranking of a hand-driven generator . . . Entirely self-contained, steady test potential of 500 volts DC, available at the touch of a switch. Direct reading in insulation resistance.

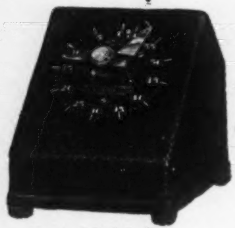
HERMAN H. STICHT CO., INC.
27 PARK PLACE NEW YORK, N. Y.

WRITE FOR BULLETIN No. 430

Timers

Interval Timers

A complete line of dependable —accurate and durable instruments



Model B

designed to use on AC Circuits to automatically open or close a single circuit at the end of a definite Time interval, or to automatically close one circuit and open the second at end of a definite Time interval.

OUTSTANDING FEATURES

Silent operation, synchronous motor with torque several times greater than that required.

Delayed start — reset stop — 12 different Time scales.

Write for Bulletin 100.

Model A

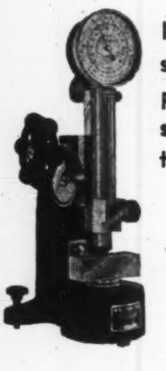
by

Cramer

The R. W. CRAMER COMPANY Inc.
CENTERBROOK CONNECTICUT

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 36 years.



In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

•

Illustrated bulletins free.

The Shore Instrument & Mfg. Co., Inc.

9025 Van Wyck Ave., Jamaica, N. Y.

REMINGTON ARMS CO. CHRONOSCOPE

Measures Time Intervals
1 to 200 Milliseconds
1% Accuracy

Inquiries Invited

Dynamometers, wattmeters, milliammeters and voltmeters. Also ultrasensitive meters both for A.C. & D.C., fluxmeters, electrostatic voltmeters from full scale 120 volts to over 20,000 volts, thermocouples, earth current meters, cable testers, etc.

Special Apparatus Built to Order

RAWSON ELECTRICAL INSTRUMENT COMPANY
110 Potter St. Cambridge, Mass.
New York, N. Y. Chicago, Ill.

Manufacturers' New Literature

In this department we report ALL pieces of new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

L-1 **"Electric Instruments, Principles of Operation."** GET-1173 presents a concise discussion of the characteristics of instruments, what makes them operate, and the individual limitations of the various types. The introduction to the publication points out that the use of electricity in manufacturing processes has become so general that the important question of whether it is being used in the most economical way is sometimes overlooked. Electric instruments are defined simply as the tools for obtaining essential information about electric circuits. Thus, a study of their construction and application invariably points the way to lower costs and improved manufacturing methods, according to the publication. General Electric Co., Schenectady, N. Y.

L-2 **Radio and Electronic Equipment.** Catalog 94, 7" × 10". Its 104 illustrated pages contain important information on new developments in radio and electronic fields for the essential war and civilian users. Listed are nearly 5,000 individual items covering the communications, testing, and radio fields. Lafayette Radio Corp., 901 W. Jackson Blvd., Chicago (7), Ill.

L-3 **Recording Thermometers.** Bulletin DM007, 8" × 10½", 6 pages describes fully-compensated, liquid-filled recording thermometers for temperature ranges between −125°F. and +400°F. Tubing lengths are up to 200 feet. Bristol Co., Waterbury 91, Conn.

L-4 **The Noise Primer.** Form 604-A, 6" × 9", 44 pages is a concise compilation of the elemental principles and procedures involved in the measurement analysis of sound and vibration. General Radio Company, Cambridge 39, Mass.

L-5 **Wheelco Comments.** The November issue of this house organ has an article entitled, "Wheelco Temperature Control Provides Ordnance Material Uniformity at Yundt Plant." Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.

L-6 **Pilot Light Assemblies.** Catalog 43, 8½" × 11", 24 pages illustrates a most extensive line of warning and signal pilot light assemblies. Dial Light Co., 90 West St., New York, N. Y.

L-7 **Aircraft Camera Mounts.** Bulletin, 8½" × 11", 16 pages describes a new principle of vibration control to protect precision flight instruments from the effects of the increased vibration due to faster planes and more powerful engines. Robinson Aviation, Inc., 730 Fifth Ave., New York 19, N. Y.

L-8 **Crystal-Actuated Mechanisms.** Bulletin, 8½" × 11", 8 pages describes

nd illustrates the Brush direct inking
scillograph to which can be fed any
t the following pickup or detecting de-
ces: strain indicators, photo electric
ells, counters, vibration pickups, heart-
eat pickups, displacement pickups or
ressure pickups. Several pages are de-
oted to the surface analyzer. Brush
evelopment Co., 3315 Perkins Ave.,
leveland, Ohio.

L-9 **Modern Precision.** The Summer
943 issue of this organ contains many
rticles covering the application of in-
truments in the process, ceramics,
ower, oil and metals industries as well
s in research, teaching and testing.
eeds & Northrup Co., 4955 Stenton Ave.,
hiladelphia, Pa.

L-10 **Transformers.** Loose-leaf folder,
½" × 11", 8 pages describes an exten-
ve line of transformers: open mounted
nits, end cased transformers, auto
ansformers, cased power pack trans-
rmers, heavy duty power transformers,
igh efficiency heavy duty power trans-
rmers, cased and filled power trans-
rmers, special transformers, unitap
ansformers and oil filled transformers.
F. Miller Co., Trenton 4, N. J.

L-11 **Insulation Breakdown Testing.**
orm A9, 8½" × 11", 4 pages describes
he Hypot all purpose insulation break-
own testing instrument. Automatic reg-
lation provides continuous burn until
sulation fault is located. Associated
esearch, Inc., 231 S. Green St., Chicago
Ill.

L-12 **Combustible Gas Recorders.**
ulletin W1801, 8" × 10½", 6 pages illus-
ates a device which measures the
mount of combustible gas or vapor
resent in gas-air or vapor-air mixtures.
udible and visible signals give warning
hen the concentration of the mixture
eaches a predetermined limit. Bristol
o., Waterbury 91, Conn.

L-13 **General Radio Experimenter.**
he November issue contains the follow-
g: Resonant Vibration in Large Engine
oundation; and Measurements of the
haracteristics of Transmission Lines..
eneral Radio Co., 30 State St., Cam-
ridge 39, Mass.

L-14 **Prisms and Lenses.** Folder, 6" ×
½", 4 pages illustrates a number of
risms and lenses. Two types of spotting
opes also are illustrated. Simpson Op-
cal Mfg. Co., 3200 West Carroll Ave.,
hicago 24, Ill.

L-15 **Photoelectric Colorimeter.** Model
0-H, 8½" × 11", 3 pages illustrates a
mpletely self-contained colorimeter op-
ated by built-in dry-cell battery.
hotovolt Corp., 95 Madison Ave., New
ork 16, N. Y.

L-16 **Electric Tachometer.** Sheet, 8½"
11", describes 2 models of a tachometer
hich provides a new step in speed
easurement for all testing, laboratory
d production requirements. Ideal Com-
utator Dresser Co., Sycamore, Ill.

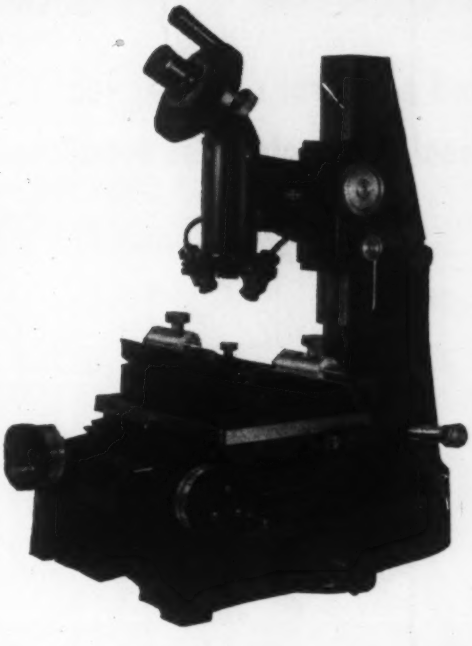
L-17 **Starter Test Stand.** Folder 8½"
11", 4 pages describes a new hydraulic
arter test stand for aircraft use. Air-
lane Manufacturing & Supply Corp.,
53 Lankershim Blvd., North Holly-
ood, Calif.

L-18 **Magnifying Mirrors.** Sheet, 8½"
11", illustrates the mirrors for watch-
g countless places where it is neces-
ry to watch an operation or dial at a
oint otherwise not visible. Larrimore
les Co., P. O. Box 1234, St. Louis 1,
o.

L-19 **Frequency Meters.** Sheet, 8½" ×
", describes direct reading frequency
dicators of the miniature, vibrating
ed type. Wirshing Manufacturing Co.,
34 Mines Ave., Los Angeles 23, Calif.

L-20 **Plugs for Aircraft Applications.**
ulletin AN, 8½" × 11", 88 pages is a
vision of a former bulletin. Leading
nstruction features of Type AN are the
lit shell with assembly ring and the
movable, interchangeable inserts. Can-
n Electric Development Co., 3209 Hum-
lt St., Los Angeles 31, Calif.

L-21 **Limited Budget Inspection Lab-
atory.** Booklet, 4½" × 7", 48 pages
iefly outlines gages and equipment for
e limited budget inspection laboratory.
eorge Scherr Co., 128 Lafayette St., New
ork 13, N. Y.



the **GAERTNER**

TOOLMAKER MICROSCOPE

for length, coordinate and angle measurements

The Gaertner Toolmaker Microscope enjoys preferential acceptance in industries devoted to the production of precision parts.

The instrument is widely used in United Nations war plants to inspect work in progress and finished work—to measure form tools, milling tools, drill jigs, templets and gauges, machine parts, taps and hobs—to perform the various thread measurements.

It is an accurate, reliable and durable instrument incorporating fine machining and carefully adjusted optical parts.

Send for Bulletin 147-14

THE
GAERTNER SCIENTIFIC CORP.
1211 Wrightwood Ave., Chicago (14), U.S.A.

TO PREVENT WASTE AND AID THE WAR EFFORT
(1) Request only the literature that will aid you. (2) Paste the coupon on a government postal card addressed to *Instruments,* taking care to make all four edges stick.

Instruments, 1117 Wolfendale St., Pittsburgh 12, Pa. (JAN. 1944)
Please have the following catalogs, etc., reviewed in this issue sent to me.

Numbers . . . .

I also desire further information concerning the following new products described in this month's "New Instruments" Department. . . . .

. . . .

I also desire further information concerning the following products advertised in this issue (Write page number and name of company). . . . .

Name . . . .
Company. . . . . Position. . . . .
Co.'s Address. . . . .
(OR) Home Address. . . . .